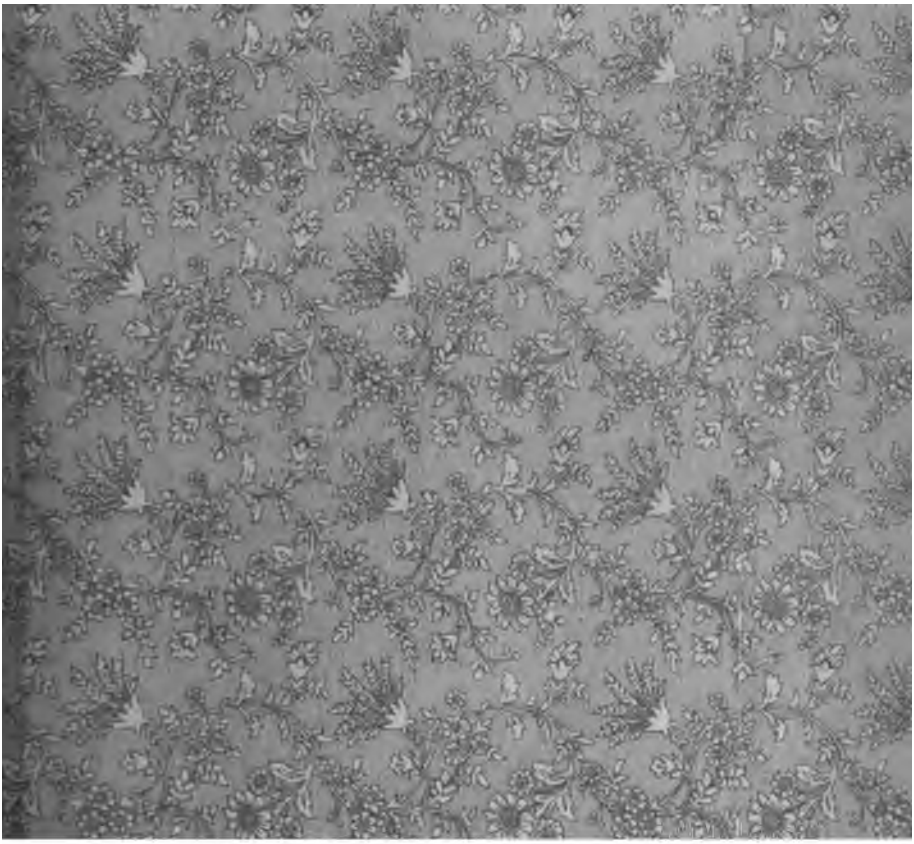


THE INSTITUTION OF CIVIL ENGINEERS.

February 4, 1873.

T. HAWKSLEY, President,
in the Chair.

No. 1,365.—"The Relative Advantages of the 5 Ft. 6 In. Gauge and of the Mètre Gauge for the State Railways of India, and particularly for those of the Punjâb." By WILLIAM THOMAS THORNTON, C.B., Secretary of the Public Works Department, India Office.[1]

THE one solitary reason of the Indian Government for adopting a narrow gauge was belief in its superior economy. The first thing, therefore, is to determine whether this economy is real or imaginary; for, although it might be real without serving as sufficient justification for the course taken, still, unless it be real, that course remains without any justification at all.

---

[1] The discussion upon this Paper extended over portions of seven evenings, but an abstract of the whole is given consecutively.

EDITORIAL NOTE.—It is considered desirable specially to draw attention to some material corrections which have been made by the Author and the speakers subsequently to the reading and discussion of this Paper. During the discussion the arguments of several of the speakers were principally addressed to the statement contained in the following paragraph of the Paper:—

"Now the programme of the Indian Government for State railways contemplated the construction in all of about 10,000 miles of such lines. By making them, therefore, on the mètre gauge, instead of on the standard gauge, Government might confidently reckon on a saving of very little, if at all, less than ten millions sterling. It had, as was at the outset admitted, but one solitary reason for its choice between the two gauges; but that reason was of the vast pecuniary weight just mentioned, and will surely henceforth be admitted to be sufficient, unless it can be shown to be counterbalanced by other considerations."[a]

On the 7th of May, 1873, a foot-note was added to the discussion by the Author, in which he says:—

"I am sorry to find myself, on further inquiry, obliged to admit that this was a considerable over-statement. The Indian Government did certainly in March, 1869, represent to the Secretary of State that about 10,000 miles were then wanting, in addition to the 5,000 miles already constructed or in process of construction, to provide India with a complete network of railways, but of those 10,000 miles, not more than 3,000 have as yet been actually marked out.—W. T. T."[b]

---

[a] *Vide* post, p. 6.   [b] *Vide* post, p. 241.

Now that, *cæteris paribus*, a narrow-gauge railway must be cheaper than a broad-gauge railway, would, as an abstract proposition, seem to be also a self-evident one. It may indeed be objected, as it has been by a high authority, that the elements which determine the cost of a railway are the size and the weight of the vehicles to be used upon it, and that it is equally possible with the same gauge to use either broad or narrow, heavy or light vehicles; and doubtless it would be possible, by furnishing a narrow-gauge line with heavy rails and other constituents, and with broad vehicles, to cause the cost to exceed that of a broad gauge with light rails and narrow vehicles. Practically, however, the broad gauge is never adopted except when broad, heavy vehicles, nor the narrow gauge, except when comparatively narrow and light vehicles, are intended to be used; and in any comparison of the two gauges this intention may always fairly be assumed. But on this assumption certain economies, more or less important, will be facilitated by the adoption of a narrow-gauge line.

There will be savings :—

1. In land, represented by a slip of the width of the difference between the two gauges, and of the length of the line of railway.
2. In earthwork, to an extent varying with the depth of the cuttings and the height of the embankments.
3. In the longitudinal and cross girders of bridgework, and also in the timber or iron covering of the same.
4. In sleepers.
5. In ballast.

Supposing the gauges compared, to be those of 3 ft. 6 in. and 5 ft. 6 in., and the weight of the rails to be the same in both, the difference of cost on these five items in favour of the narrower gauge is, by Mr. Hawkshaw, estimated as follows :—

	£	
Land	10	per mile.
Earthwork.	100	„
Bridgework	50	„
Sleepers, and ballast	200	„
Total	£360	„

By Mr. Fowler, who omits to take land into account, the other savings are calculated as follows :—

	£	
Earthwork	37	per mile.
Bridgework	83	"
Sleepers, ballast, and laying . . .	503	"
	£623	"
Or, with addition for land of . . .	10	"
Total	£633	"

	£
Taking the mean between these totals, namely	497
And adding, as Mr. Fowler does, for diminished cost of engineering and agency	87
And, as Mr. Hawkshaw does, for saving in maintenance and renewal of permanent way, at £10 per mile, capitalized at 20 years' purchase	200
There is a fresh total of	£784

which may be fairly claimed as representing (according to the average of the judgments of these authorities), the superior cheapness of an Indian railway of 3 ft. 6 in. gauge over one of 5 ft. 6 in. gauge. Mr. Hawkshaw, indeed, considers that a further saving of £200 a mile should be allowed as obtainable by the use of sharper curves; and, as among the State railways contemplated there are some, like the Carwar-Hooblee, Khundwa-Indore, and Lahore-Peshawur lines, traversing exceedingly hilly and even mountainous tracts, the allowance does not seem too great, and, being added to the sum of the previously mentioned items, would bring up the total to £984 a mile.

Another saving of £200 a mile is conceded by Mr. Hawkshaw, under the head of locomotives; but as, although including this in his estimate, he shows apparently conclusive reasons why it ought not to be included, it will here be disregarded, nor will the comparative trifle of £12 per mile, allowed by Mr. Fowler on the same account, be taken credit for.

After all reasonable deductions then, the saving obtainable by the adoption of a 3 ft. 6 in. gauge is, according to the verdict of by no means over-favourable judges, at least £784, if not £984 per mile. But the gauge actually selected by the Indian Government is one of 3 ft. 3 in., or the so-called mètre gauge; and as, according to Mr. Fowler, a reduction of the gauge from 3 ft. 6 in. to 2 ft. 9 in. would, in India, make a difference in cost of £110 per mile, a reduction to 3 ft. 3 in. would, rateably, reduce the cost by nearly £37 per mile, thereby raising the total saving to £821 per mile, or to £1,021 per mile, according as the economy possibly

referable to sharper curves be, or be not, taken into account. Perhaps the fairest plan will be to split the difference, and to assume that, as a general rule, a railway in India on the mètre gauge would be cheaper than an equally substantial line on a 5 ft. 6 in. gauge by £921, or, in numbers rounded by the addition of the capitalized value of a further saving on annual repairs, by £1,000 per mile.

Now the programme of the Indian Government for State railways contemplated the construction in all of about 10,000 miles of such lines. By making them, therefore, on the mètre gauge, instead of on the standard gauge, Government might confidently reckon on a saving of very little, if at all, less than ten millions sterling. It had, as was at the outset admitted, but one solitary reason for its choice between the two gauges; but that reason was of the vast pecuniary weight just mentioned, and will surely henceforth be admitted to be sufficient, unless it can be shown to be counterbalanced by other considerations.

It will scarcely be argued that the transport of the utmost amount of traffic to be expected on any of the contemplated lines would be beyond the capacity of the mètre gauge. On the contrary, there are, probably, few who will not admit that, if railway construction in India were now being for the first time introduced, it might be wiser to have all, even of the existing lines, that is to say, all those of the guaranteed companies, either on the mètre gauge, or, at any rate, on some gauge a good deal narrower than the present Indian standard—say, for example, on one of 3 ft. 6 in. If the traffic on the existing guaranteed lines were anything like what it was originally expected to be—were of anything like the amount for which the lines were designed, and on which the original shareholders fondly reckoned—they would surely be yielding much more nearly 10 per cent. than 5 per cent. on their cost. What they are on an average really yielding is, however, less than 3 per cent.; whence it may be safely inferred that their present traffic is certainly not three-fifths, and is most probably not three-tenths, of what, with their actual standard gauge, they could carry; nor, therefore, more, if indeed nearly so much, as they could carry, if their gauge were less by two-fifths than the standard gauge. But, if this narrower gauge would suffice for the traffic of the existing guaranteed lines, of course it would be more than sufficient for that of the projected State lines, which, in a commercial sense, are so much less promising.

A narrow gauge being then plainly sufficient for the State lines,

regarded by themselves separately, and without reference to any larger system with which they might be connected, the only objection to the adoption of such a gauge is that of the disadvantages of break of gauge. The extreme gravity of those disadvantages need not as yet be questioned. For the present, and for the sake of argument, they may be admitted to the fullest extent that any one may desire; for, in regard to the immediate issue, there is no place for any argument arising out of them.

The position of the Indian Government, when first conceiving its State railway policy, may be sufficiently understood from what the position is now: to wit, as follows. On about £90,000,000 sterling, expended by railway companies on about 5,000 miles of open railway, it guarantees interest to the extent of £4,500,000 per annum; while the net earnings of all the guaranteed lines, in the last year for which returns have been received, were somewhat less than £2,840,000; leaving £1,660,000 for the Indian tax-payer to make up. On the reasonable supposition that the rates and fares of the guaranteed railways are fixed with a view to the production of the largest possible revenue, their gross earnings may be regarded as representing what the people of India, for whose benefit the railways were made, are willing to pay for such benefits; in other words, what, in their opinion, these benefits are worth. By being made to pay for the said benefits £1,660,000 over and above the amount represented by the gross earnings, they are plainly paying £1,660,000 more than the persons who use the railways, and who ought to be tolerably good judges of that particular point, do believe the said benefits to be worth.

Whether the Indian Government was warranted in forcing railway blessings on its subjects, at a price so far above the market-rate, may be an open question; but there can be no doubt that to such forcing there ought to be a limit. Most assuredly it can be no just ground of reproach against the Government, to have been satisfied with compelling its subjects to pay so exorbitantly for the use of the 5,000 miles of railway already made, and to have determined, with respect to the 10,000 miles remaining to be executed, that they should, if possible, be constructed so cheaply, that the receipts from customers would suffice to pay full interest on their cost, without requiring to be supplemented out of taxes. But, even with all the extra cheapness attendant on the narrow gauge, scarcely any of the projected State lines are expected to be quite cheap enough for this; indeed, were it not that they are expected to be strategically and politically, as well as commercially, useful, scarcely any of them could, consistently with the Government's

present sense of duty, have been permitted to be made. But, under such circumstances, for Government to allow the cost of the railways to be increased by ten millions sterling, in order to avoid the evils, however great they might be, of break of gauge, was plainly out of the question. The choice did not lie between narrow-gauge railways and broad-gauge railways, but between narrow-gauge railways and no railways at all; and those who disapprove of such limitation of choice must be prepared to prove that the break of gauge, however bad it may be, is not still an important improvement upon the previously existing break between railways and common roads.

Thus much in regard to the preliminary and more comprehensive question. But, although the narrow gauge may be the more suitable for Indian State railways generally, there may be particular localities for which, owing to particular circumstances, the broad gauge would be better adapted; and an opinion is widely spread, and authoritatively maintained, that one such locality is the territory included within what may be termed the Punjâb Railway system. The arguments in support of that opinion have been urged with equal force and fairness by Mr. Fowler. That gentleman is not one of those who deem it sufficient to demonstrate the truism, that for all carrying purposes, a broad gauge is, *cæteris paribus*, superior to a narrower gauge. He has distinctly recognised that, "in some districts of India, the population is so sparse, the goods for railway transit so few, and the probability of much increase so remote, that cheap narrow-gauge railways may be introduced with financial and local advantages;" and he has, with equal explicitness, further stated, with special reference to the Indus Valley, that, were it not for certain sections of railway having already been constructed there, he should have "found very little difficulty in deciding in favour of a narrow-gauge line, from its suitability to the very light traffic of that district, and also from its presenting one point of contact only—namely, at Lahore—with the standard gauge." He apprehends, however, in common with all other objectors to this part of the Government plan, that the fact of two sections—both on the standard gauge—already existing, one from Lahore to Mooltan, and the other from Kotree to Kurrachee, would, in the event of the other sections being constructed on a narrower gauge, necessitate extra expenditure so heavy as to more than neutralize the economy immediately attendant on such construction. It is essential, for the vindication of Government, that these apprehensions should be shown to be groundless.

The case stands thus: Continuous railway communication from Peshawur to Kurrachee, a distance altogether of 1,092 miles, being the desideratum, two sections, namely, from Lahore to Mooltan, 214 miles, and from Kotree to Kurrachee, 105 miles, 319 miles together, have been made; while two, namely, from Peshawur to Lahore, 280 miles, and from Mooltan to Kotree, 493 miles, together 773 miles, remain to be made.

Now the total saving obtainable on these two latter sections by the adoption of the mètre gauge, instead of the 5 ft. 6 in. gauge, has been calculated in detail by Mr. Fowler, and also by Mr. Lee Smith, with results which, after certain necessary corrections for inaccuracies in matters of fact, may be exhibited as follows:—

Mr. Fowler's Estimate (not including Indus Crossings).

—	5 Ft. 6 In. Gauge. Cost per Mile.	3 Ft. 6 In. Gauge. Cost per Mile.	Difference per Mile.		Addition for Reduction to Mètre Gauge.		Total Saving per Mile.		Total Mileage.	Total Saving.
	£	£	£		£		£			£
Peshawur to Lahore	9,021	8,227	794	+	37	=	831	×	280	232,680
Mooltan to Kotree .	6,367	5,501	866	+	37	=	903	×	493	445,179
										£677,859

Mr. Lee Smith's Estimate (including Indus Crossings).

—	5 Ft. 6 In. Gauge. Total Cost.	3 Ft. 3 In. Gauge. Total Cost.		Deduct on Account of 30 Miles difference in Length between Lines compared.		—	Total Saving.	Grand Total.
	£	£		£		£	£	£
Peshawur to Lahore	3,712,440	3,882,375	−	348,060	=	3,534,315	178,125	
Mooltan to Kotree .	3,895,631	3,161,277	.	. . .	.	. . .	734,354	
								£912,479

Assuming, on the grounds stated in the early part of this Paper, the rate of saving to be £1,000 per mile, the total saving by constructing both the Lahore-Peshawur, and the Mooltan-Kotree sections on the mètre gauge, instead of on the standard gauge, will be £773,000. By the engineers of the Indian Government it is, according to the latest advices, estimated at £750,000.

To recapitulate—the total saving by the adoption of the mètre gauge on the two sections in question is estimated :—

	£
By Mr. Fowler, at about	680,000
By Mr. Lee Smith, at a little more than	900,000
By the Engineers of the Indian Government	750,000
On a balance struck between Mr. Fowler and Mr. Hawkshaw, it may be taken at	770,000

In the calculations about to be made, the figures employed will be those of Mr. Fowler, as being the least favourable to the Government.

The two existing sections of the Punjâb system being on the standard gauge, if the one mètre-gauge section is to be interposed between them, and another placed as an outside link of the whole chain, the combination of the four sections will result rather in a series of most inconvenient dislocations, than in anything deserving to be styled a system, unless each of the standard-gauge sections be either fitted with a third rail, or have one of its rails taken up and relaid on the mètre gauge. Mr. Fowler recommends, as the next best plan to the standard gauge throughout, that a third rail should be laid from Lahore to Mooltan, and that the rails between Kotree and Kurrachee should be relaid at mètre distance, and the cost of the two operations is estimated by him at £327,177, which, being deducted from the saving of £680,000, obtainable by making the two new sections on the mètre gauge, would leave a balance of only £352,823.

The necessity for this deduction is not to be gainsaid; but Mr. Fowler likewise demands another of £320,700, for the provision of rolling stock for working through-traffic on the narrow gauge between Mooltan and Lahore, and also for an extra supply of narrow-gauge rolling stock from Kurrachee to Peshawur for military contingencies; and this demand he makes on the assumption that the narrow gauge employed is to be 3 ft. 6 in. If he had assumed a mètre gauge, his claim would have been proportionately increased.

By deducting, however, only the lesser sum actually stated, he would bring down the original saving of £680,000 to about £30,000; and it must, in candour, be owned, that not only does

Mr. Lee Smith, but likewise General Strachey, Colonel Dickens, and Mr. Meadows Rendel, whose bias may reasonably be supposed to be towards the Government plans, quite concur in recognising the principle on which the greater part of this second deduction of Mr. Fowler's is proposed by him to be made.

Nevertheless, and notwithstanding so imposing an array of adverse authority, it is respectfully submitted that not the smallest deduction on this account ought to be allowed.

Considering, first, the section from Mooltan to Lahore, the existing quantity of broad-gauge rolling stock thereon either is sufficient for all expected traffic, whether through, or local, or it is not. If it is not, then, in case the broad gauge had been adopted for the adjoining sections also, it would have been indispensable to provide additional broad-gauge rolling stock for the Mooltan-Lahore section; the cost of which addition would certainly have been at least equal to that of the quantity of mètre-gauge stock requisite in order to render the total amount of rolling stock, broad and narrow, capable of conveying all the traffic on a mixed gauge. If, on the other hand, the present quantity of broad-gauge rolling stock be sufficient, then, when supplemented by a quantity of mètre-gauge rolling stock for use on a mixed gauge, the total of broad-gauge stock would obviously be in excess of the quantity required, to the exact extent to which it had been supplemented by narrow-gauge stock; and the difference would be available for sale or transfer to the broad-gauge lines, the sale proceeds or appraised value serving as a complete set-off against the money spent on the narrow-gauge stock.

Similarly, for the Lahore-Peshawur section, the cost of providing rolling stock sufficient for ordinary traffic would be the same whether the gauge were broad or narrow, or the difference, if there were any, would be in favour of the mètre gauge; so that, whatever necessity there was for providing additional stock for military contingencies, the necessity would be the same for both gauges, the cost also being the same, or, if anything, less for the narrow gauge. It is thus abundantly clear that, in comparing the cost of the proposed mixed gauge with that of the standard gauge, for the entire Punjâb system, there is no valid reason for augmenting the former with one penny on account of extra rolling stock; and, the addition made on that account by Mr. Fowler being withdrawn, the saving by the adoption of the mixed gauge remains, as virtually admitted by himself, at £352,823.

Here, however, it must be pointed out that all comparisons hitherto made, whether by Mr. Fowler or others, between broad

and narrow gauge for the Punjâb, have proceeded on the supposition that the Punjâb railway system will be complete when, by the filling up of the present gap between Kotree and Lahore, and by an extension from Lahore to Peshawur, a continuous trunk line shall have been formed from the last-named town to the port of Kurrachee. This, however, is by no means the case. The purposes which the Punjâb system of railways has in view are rather strategical than commercial, and will be very imperfectly answered, unless one branch at least be led off westward from the trunk line. The branch particularly referred to is one of about 180 miles, starting from Sukkur, on the Indus, and terminating, in the first instance, at Dadur, at the mouth of the Bolan Pass. This is a work almost certain to follow very speedily upon the completion of the trunk line, and all the more speedily by reason of the sense of common interest which is fast growing up between British India and Afghanistan, in view of Russia's portentously rapid progress in Central Asia. It is further to be noted, that the connection of the Indus Valley railways with those of Rajpootana is a project regarded by the Indian Government as one which may deserve to be undertaken at some future period. The aggregate length of these prospective lines could scarcely be less than 400 miles; and, as the determination of their gauge would obviously depend upon the one selected for those of the Indus Valley, the choice of the mètre gauge instead of the standard gauge for these latter would, taking £1,000 per mile as the difference of cost between the two, occasion a saving of £400,000 upon the prospective lines. Of this additional sum, however, only the £180,000 assignable to the Dadur line shall here be taken into account; but that much being added to the £352,823, with which the narrow gauge has already been shown to be on Mr. Fowler's principles entitled to be credited in respect to the Punjâb, will raise the total saving consequent on its adoption in that quarter to £532,823.

This being premised, the inquiry may now be made as to what extent such large pecuniary advantage would be counterbalanced by the disadvantages consequent on break of gauge. Here it is at the outset to be observed that the disadvantages in question, consisting mainly in what may, with respect to passengers as well as goods, be termed break of bulk by change of carriages, would, so far as import traffic is concerned, be only partially obviated by the adoption of a light standard, instead of a light mètre, gauge. The only railway that abuts on the Punjâb from the east being, like all other railways of the guaranteed companies, laid

with rails heavier by one-third than those proposed for the Punjâb, even by the advocates of the broad gauge, their proportionably heavier engines could not travel on the Punjâb light lines without ruining them. All through-traffic entering the Punjâb from the eastward would, therefore, have to change engines, if not carriages; and the trains of carriages, if not changed, would have to be broken up and divided into shorter trains, in order to admit of their being hauled by the less powerful engines of the light lines. On the other hand, the export traffic trains, when entering on the heavy lines to the eastward, would either continue to be hauled by light engines unequal to heavy-line speed, or, if taken in tow by heavy-line engines, would be hauled by those engines at the expense of considerable waste of power.

Still, it cannot be denied that some evil would be attendant on the break of gauge. All that is desired is to prevent its being exaggerated. An endeavour will now be made to determine as nearly as possible its real amount.

The evil in the case of the Punjâb is of two kinds—mercantile and strategical; for the inconvenience to which private passengers might be subjected, by having to change carriages once in a long journey, is as little worthy of serious consideration, as that which all suffer through having occasionally to take a cab to a station instead of being able to enter a train from our own doorstep. As regards goods, the gravity of the evil may be measured by the quantity of goods that would have to be transladen. There are two points at which such translading might take place, Lahore and Mooltan; at Lahore, of goods either arriving from the north and proceeding in the direction of Umritsur and Delhi, or arriving from Umritsur, or places beyond, and proceeding towards Peshawur; at Mooltan, either of goods arriving from the south and destined for ulterior conveyance by the broad gauge east of Lahore, or of goods which, having been brought by the same lines to Lahore for conveyance to places south of Mooltan, had not been transferred to the narrow gauge at Lahore, and therefore required to be so transferred at Mooltan. Now, of these last two descriptions of goods the quantity may be safely pronounced to be *nil*. According to the latest trade statistics, the total imports into Mooltan from all places east of Lahore was, in 1870-71, only 10,530 tons, the exports from Mooltan to the same places being under 2,400 tons; and a glance at the map will suffice to show that no appreciable portion of this insignificant traffic can have emanated from, or been destined for, the half-desert tracts extending for a considerable distance to the south of Mooltan.

At Lahore, the other point of meeting of the gauges, the state of things is somewhat, but not materially, different. The quantity of traffic passing through that city in 1870-71, either from the eastward towards Peshawur, or eastwardly from Peshawur and places intermediate, was, according to the same statistical tables, as follows :—

Imports	414 tons.
Exports	112 „
Total	526 „

Supposing that, on the completion of the Lahore and Peshawur railway, these quantities will be doubled—becoming a total of 1,052 tons; and that the out-turn of the Jhelum salt mines will simultaneously rise from 40,000 tons to 100,000 tons, and that not more than one-half of this quantity will either be consumed within the territory of the five rivers or sent westward into Afghanistan, the other half being exported in the direction of Delhi, notwithstanding that only 13,000 tons seem to be as yet so exported annually, and notwithstanding also that it will thereupon come almost immediately into competition with the produce of the Sambhur Lake, even then, and after all this amplification, the aggregate traffic compelled, by break of gauge, to break bulk at Lahore will be no more than 51,052 tons. Now fourpence per ton is pretty generally considered to be the maximum representative in cash of the commercial ill-effects of break of gauge; 51,052 fourpences, therefore, or £850 per annum, or interest at £5 per cent. on a principal of £17,000, represents the utmost commercial harm that can be expected to be done by break of gauge between the railway systems of the Punjâb and of the rest of India. The considerations that recommend an extra outlay of between £500,000 and £600,000 to prevent £17,000 worth of harm must needs be other than commercial.

The strategic considerations are these :—

First. With the Punjâb lines on the mètre gauge, all troops and military stores arriving at Lahore, *en route* either for places south of Mooltan, or for places in the direction of Peshawur, would have to change carriages at Mooltan or Lahore. Secondly. However grave the emergency, only the bare rolling stock of the Punjâb lines themselves will be available for transport upon them; whereas, if those lines were broad-gauge, their rolling stock might be supplemented to any extent by draughts upon the 5,000 miles of broad-gauge lines eastward of the Indus. This is the character

of the strategical evils. Their imagined importance may of course be magnified or diminished at pleasure, and there will perhaps be no great difficulty in showing that their importance is somewhat unduly magnified by those who, like a distinguished Member of this Institution, "take for granted" that a prominent motive for establishing continuous railway communication between Peshawur and Kurrachee is the facility which will thereby be afforded "for moving large masses of troops, and for concentrating them in particular districts in the quickest possible time." The only conceivable contingencies in which the presence of large masses of troops will be required in the Punjâb are such as, like, for instance, a Russian invasion, cannot fail to cast their shadows before them so long beforehand, as to allow the Indian Government, without the least hurry and with the most complete deliberation, not only to mass whatever troops, artillery, and military stores might be deemed necessary at Lahore as a basis of operations, but also to distribute troops fully equipped amongst whatever advanced posts it might think proper to occupy. Thenceforward the broad-gauge railways of the main Indian system would never have to bring up troops to be passed on through Lahore without stopping. Their share in the business of the campaign would consist in maintaining, at its proper complement, the reserve of men and material at Lahore. Or if, in some unforeseen emergency, a regiment ever did arrive by rail at Lahore requiring to be sent forward immediately, the only time lost would be the half-hour or so spent by the men in walking from the broad-gauge train to a narrow-gauge train, already laden, in anticipation of their arrival, with whatever guns, ammunition, &c., were needed for their full equipment. This occasional half-hour or so would be the only delay (if any) which ever could be caused by break of gauge.

Respecting the restriction of the projected Punjâb lines to their own proper rolling stock, and their inability to borrow from the main Indian system, it is, in the first place, to be observed that, even though the Punjâb lines were of the standard gauge, it is only carriages and wagons that they could borrow from heavy broad-gauge lines. Heavy-line engines could not be permitted to travel upon their light rails; so that, in order to be able to utilize on emergency the borrowed vehicles, it would be necessary always to maintain on the Punjâb lines a duly-proportioned number of reserve engines to haul them, the enormous expense of which would of itself be an insuperable objection to borrowing.

Secondly. Even though this difficulty did not exist, and even

though all the engines and all the vehicles of the 5,000 miles of broad gauge were capable of being used, and available for use, on the Punjâb lines, there would be not the smallest occasion for them there. The rolling stock of the Punjâb lines themselves would be equal to all possible demands. The neighbourhood of Peshawur, near the entrance of the Khyber Pass, and the neighbourhood of Dadur, at the mouth of the Bolan Pass, are the only localities at which an European, or Europeanized, invader would have to be encountered. Let him, then, be supposed to make his appearance simultaneously at both places, and, to put the case as badly as possible, let a host of Beloochees be supposed to be at the same time giving trouble anywhere between Kurrachee and Sukkur. Even then no question of moving by rail complete army corps could arise. Unless the very genius of folly had presided over the previous dispositions, the despatch for a few days together of a regiment a day, every alternate day, from Lahore towards Peshawur, and from Lahore to Dadur, and of a regiment northwards from Kurrachee, as often as one arrived at that port by sea, is the utmost requirement to be seriously contemplated. Now, although the provision of rolling stock for the future Punjâb lines is intended to be much below that of most existing Indian railways—although, while, according to Mr. Hawkshaw, the average complement of the latter is about one engine, with vehicles in proportion, for every five miles, the Government authorities are of opinion that for the lesser traffic of the Punjâb one engine and thirty vehicles for every thirteen miles may possibly suffice—yet, even with rolling stock at this exceedingly low rate, it has been demonstrated by careful and minutely detailed calculations that, in the course of a week, 12,000 combatants of all arms, infantry, cavalry, and artillery, fully equipped, and with a month's rations, could easily be moved from Lahore to Sukkur, or 11,000 from Lahore to Peshawur, or three corps of 4,000 each, one from Lahore to Peshawur, a second from Lahore to Sukkur, and a third from Kurrachee to Sukkur.

The case for the Government of India stands thus: By making the Punjâb lines on the mètre gauge it will save £530,000, at the lowest computation. To have adopted a light standard, instead of a mètre gauge, would have occasioned a waste of a like amount. against which there would not have been the smallest strategical set-off, nor any other compensation of any kind, except a slightly increased commercial convenience, not exceeding in capitalized value £17,000 at the outside.

It remains only to be said that this vindication of the Indian

Government is offered by a volunteer advocate, who does not pretend to have received a brief. Quite possibly therefore he may have inadequately treated some points, or even completely overlooked others, on which that Government, if consulted, might have desired to lay especial stress.

The Paper is illustrated by a map, from which Plate 8 has been compiled.

Mr. W. P. Andrew (Chairman of the Scinde, Punjâb, and Delhi railways) said he had listened to the Paper with much interest and satisfaction; inasmuch as it was the production of a well-known advocate of the proposed narrow gauge; and because it showed how little, even in such skilful and practised hands, could be said in favour of a crotchet which, if imported into the railway system of India, would utterly destroy the usefulness and importance of the lines which he had the honour to represent.

In the first place, he would endeavour to clear the ground by saying that cheap railways, and a break of gauge, were two distinct questions. Twenty years ago he had himself advocated the introduction of cheap railways into India, and he had heard nothing novel in the Paper read on this occasion unless it were the gauge of 3 ft. $3\frac{3}{8}$ in., and that a break of gauge was no serious disadvantage.

The Paper would lead the Institution to imagine that the Author, like Rip Van Winkle, had been asleep for the last twenty-five years, and that he had never heard of the disasters, the confusion, and the loss that had occurred in England from a break of gauge: as he had now proposed, for adoption, ideas which men, who had not been asleep, had long since found impracticable, and had therefore abandoned. All who were interested in railways, in India, must deplore the delay which had occurred from the discussion of this most unfortunate crotchet. All must deplore that the Indus Valley line of railway had been so long delayed, inasmuch as it was beyond question the most important political and strategic line in India—looking to the portentous approach of Russia towards the confines of the Indian empire. Of all the most eminent men connected with India—and he had been in correspondence with a great many—there was not a single one who had not attached the utmost strategic value to the Indus Valley line: Lord Lawrence, Sir Bartle Frere, the late lamented Sir Donald McLeod, Lord Napier of Magdala, and many others, all attached the greatest importance to it; and was it now to be supposed that the Government was going to make this great line almost worthless, for political purposes? The Government proposed to introduce within Indian territory a break of gauge —the very means—be it observed—which Russia had established at her frontier to hamper the movements of any invader. Had a break of gauge existed between France and Germany, the siege of Paris would, in all probability, never have taken place. It was evident that this 'toy line,' which was proposed, could never carry heavy ordnance, and horses, and the munitions of

war, with rapidity, certainty, and despatch. Many eminent engineers had told him that it was impossible: at all events, it must be admitted that it could not carry those heavy munitions of war with the same ease and certainty as a line of wider gauge.

The existing gauge was introduced under the authority of Lord Dalhousie, after very considerable investigation, and there did not appear to be any reasonable objection to it. As to saying that a break of gauge was a matter of very little importance, from the Author's description of a regiment marching from one line to another, with all the munitions and all the artillery comfortably arranged in another train on another gauge on the other side of the platform—one would have thought he was organising a pleasant excursion to the 'Star and Garter' at Richmond, instead of handling a body of troops with their camp followers and baggage. He made no reference to the failures and confusion incident to the management of a large body of men and a large amount of heavy material under such circumstances. The real evils were well known to all who were connected with the management of railways. Mr. Andrew trusted there were some present who would give their experience of the evils, confusion, and loss, incident to a break of gauge on the Great Western line. If so, they would state that the evils were so great that, sooner than continue to suffer the loss and confusion, they were induced to relay the line, and to make it a continuous narrow-gauge line instead of a broad-gauge line.

The difficulty and confusion involved in the movement of troops, especially in a country like India, although considered of little account by the Author, were well known to those who had had any experience of campaigns in that country. Even if the fear of complications arising from the portentous advances of Russia should prove to be exaggerated, or groundless, there were ample reasons of a political and strategic character why the railway system of the north-western frontier should be made as perfectly adapted as possible for strategic purposes, instead of being rendered inefficient and comparatively useless, as it would be if a break of gauge was introduced. It was well known with what rapidity the spirit of hostility spread among the fanatic tribes who composed the population both of portions of the British Indian territory and of that immediately beyond the borders. As an instance of this, he might mention the case of the Umbeyla campaign, about ten years since. When this campaign was undertaken, a well equipped force of about 5,000 men was considered sufficient.

But when this force had occupied the Umbeyla Pass, the General commanding found it would not be prudent to advance further without first obtaining a reinforcement of 2,000 men to hold the pass, which was only about 40 miles from Attock and 3 miles beyond the border. And so rapidly did the spirit of hostility spread among the fanatic tribes along the frontier, that, by the time the desired reinforcement arrived, a second reinforcement was found to be required, thus rendering the movement of regiments repeatedly necessary from post to post along the line by which the troops advanced. It was the opinion of the highest authorities on the spot that had 2,000 men been promptly available in the first instance, the putting down of the outbreak would have been the work of a few days, instead of being one of considerable time and difficulty, and attended with heavy loss of life as well as with great expenditure of money.

Mr. Andrew felt, personally, a special interest in this question, inasmuch as he had planned and advocated for many years past the Indus Valley system of railways, with branches to the Khyber and Bolan passes. He feared the Government were by no means alive to the great political importance of that system of railways, which, not only for commercial purposes, but still more for political and strategic reasons, he desired to see completed in the most efficient manner possible. In illustration of the imperial importance of this question, he might be permitted to quote some remarks which he had addressed to Lord Palmerston, in 1857, when Mr. Andrew headed a large and influential deputation to urge upon the support of Government the claims of the proposed Euphrates Valley Railway. On that occasion he stated that "The grand object was to connect England with the north-west frontier of India by steam transit through the Euphrates and Indus Valleys. The latter would render movable to either the Khyber or the Bolan, the two gates of India, the flower of the British army cantoned in the Punjâb; and the Euphrates and Indus lines being connected by means of steamers, we should be enabled to threaten the flank and rear of any force advancing through Persia towards India. So that the invasion of India would by this great scheme be placed beyond even speculation; and it would be evident that the great army of India of 300,000 men, being united by this means to the army of England, the mutual support they would render each other would quadruple the power and ascendancy of this country, and promote powerfully the progress, and the freedom, and the peace of the world."

He could not agree with the Author that it was probable we should have ample notice of any hostile movement on the part

of the Russians to enable due preparations to be made for their reception.

There was one circumstance that the Author had alluded to, regarding the tax-payer of India. Now, India was a great country—possessing two hundred millions of people—as large as the whole of Europe exclusive of Russia. The commerce of the country, since railways were introduced, had increased at an enormous rate. Those who, like himself, were connected with Indian railways, had sent out about 6,000,000 tons of materials, conveyed in between 7,000 and 8,000 ships; and they did imagine that the large amount of money they had sent out also had had some beneficial effect on this very pitiable and most interesting tax-payer. They had sent out money for investment in India; and they thought if the Indian tax-payer had to pay £1,600,000 per annum, to make up the guaranteed interest on the railways, the tax-payer had reaped some little advantage in having, in many instances, three times the usual wages; in being well clothed instead of being almost naked, and being well fed instead of half starved; and the farmer, in the enhanced prices of produce and the increased cultivation of the land; and the merchant, in the facilities for the transport and sale of his goods, had benefited to an enormous extent from British capital—not Indian capital. And what was it the tax-payer had to pay? £1,600,000 per annum for all these enormous benefits! It was less than twopence per head. He did not think it fair to bring forward the tax-payer without stating at the same time what he got for his money. If he paid two-pence he got not only a very good sixpence in return, but other benefits which at present he could not estimate.

The commerce of India, as he had already stated, increased to an enormous extent after the introduction of railways. In 1834–35 it amounted to fourteen millions sterling. Then there were no railways. In 1854–55 it amounted to about thirty-five millions, when there were 150 miles of railway constructed. From that time it increased at the rate of eight millions per annum till 1865–66, when it amounted to one hundred and twenty-three millions sterling. That the commerce had not increased since that period was owing to exceptional circumstances, which he had no doubt would soon pass away.

The following memorandum would show the rapid increase which had taken place in the trade and revenue of India during recent years, since the introduction of railways into that country:—

Trade of India.

Year.	Imports.	Exports.	Total.	Remarks.
	£	£	£	
1834–35			14,000,000	Average increase from 1834–35 to 1854–55 about £1,000,000 sterling per annum, there being in 1854-55 only about 150 miles of railway open.
1854–55			35,000,000	
1861–62	37,272,417	37,000,397	74,272,814	Average increase from 1854–55 to 1870–71, during which period the railways have been rapidly pushed forward, upwards of £3,500,000 per annum.
1862–63	43,141,351	48,970,785	92,112,136	
1863–64	50,108,171	66,895,884	117,004,055	
1864–65	49,514,275	69,471,794	118,986,069	
1865–66	56,156,529	67,656,477	123,813,006	
1866–67[1]	42,275,619[1]	44,291,497[1]	86,567,116[1]	
1867–68	47,481,157	52,446,002	99,927 159	
1868–69	51,146,095	54,457,744	105,603,839	
1869–70	46,882,326	53,513,728	100,396,054	
1870–71	38,858,728	57,818,022	96,676,750	

[1] Eleven months only.

Revenue of India.

Year.	Amount.
	£
1850	27,522,337
1855	29,133,050
1860	39,705,022
1865	45,652,897
1870	50,901,081
1871	51,413,686

Debt of India in 1871.

£111,542,208, or little more than two years' revenue.

Alluding to the Punjâb railway, the Author had mentioned the small traffic which existed on that line, but Mr. Andrew would like to know whose fault it was that the traffic was small? They had in Scinde 106 miles of railway, and in the Punjâb 550 miles, with a gap between of 480 miles. They had, as it were, one part of the line in France and the other part in Spain, with an interval between, and they were not allowed to make the intervening link; and yet they were told it was a line of small traffic. Nothing could be more unreasonable. The Punjâb, which had been described as the "Bulwark of British India," was an immense territory, comprising within its borders an area of nearly

200,000 square miles, with a population of 22,000,000 subject to British rule or influence. So great were its capabilities that it had been estimated by Lord Lawrence, when Chief Commissioner of the Province, to be capable of producing half a million tons of cereals for export annually, without in the least degree interfering with the requirements of the inhabitants themselves.

The charge for transhipment of goods from one gauge to another was estimated by the Author at 4*d.* per ton. Now it would be found from Mr. Hawkshaw's report, that at the time the discussion relative to the gauges was going on, one person estimated it at 4*d.*, another at 8*d.*, and another at 1*s.* per ton; but Mr. Hawkshaw stated that all these estimates were fallacious, inasmuch as the loss arising from confusion and delay exceeded infinitely either of those sums.

In contrast to the views entertained by the Author, who, for the one solitary reason of a so-called economy, would seriously impair the efficiency of this most important portion of the very backbone of the Indian railway system, it should be mentioned that Lord Salisbury, in a speech at Manchester in 1868, in reference to proposed railways in India, had urged that Government ought not solely to regard the question as one of direct profit, as he considered that even in the case of lines which did not yield a direct profit, the Government were more than compensated for any outlay which they incurred. There might also be mentioned a despatch addressed by Sir Stafford Northcote, when Secretary of State, to the Governor General on the 24th of November, 1868. In this despatch the Secretary of State observed:—"The political and military advantages of present commercial railways to the Government would be cheaply purchased even were the railway system more costly to the Government than it is." It could only be hoped that the question which the Members were assembled to discuss would yet be decided on broader and more worthy grounds than those adduced by the Author.

Mr. T. E. Harrison, V.P., said that he would endeavour strictly to confine himself to the arguments of the Paper. He might say, at the outset, that he had had no connection with Indian railways, but in England he had not only constructed many hundreds of miles of railways, but he had also had to work and manage them; and in the observations which he proposed to address to the meeting he would draw from the experience he had so gained, to illustrate the views to which he proposed to give expression.

The Paper stated that, "practically, the broad gauge is never

adopted except when broad, heavy vehicles, nor the narrow gauge, except when comparatively narrow and light vehicles, are intended to be used." Now he took exception to that being laid down as a matter of fact. The original Newcastle and Carlisle railway, which was 60 miles in length, was worked for upwards of twenty years entirely by light engines, light carriages, and light wagons, and he believed that some of that railway stock was still in existence after nearly forty years of wear; and to say that only heavy vehicles were introduced on broad-gauge lines was a mistake, because many of the goods wagons referred to did not weigh more than 2¼ tons or 2½ tons, and carried 5 tons of load. Again, it was not true as regarded the narrow-gauge lines, because, in Canada, on the Grey and Bruce and Toronto railway, the cars in use upon that line, though of only 3 ft. 6 in. gauge, were 8 ft. wide and 36 ft. long: therefore when he saw such a statement as that, he could not but call attention to it as not being in accordance with facts.

He would now proceed to the question of figures. It was broadly stated, in the commencement of the Paper, that the case of the Indian Government was based upon one solitary reason—that of economy; and it was admitted that the whole question depended upon whether that economy was real or imaginary. The Author gave two estimates made by men of great eminence—Mr. Hawkshaw and Mr. Fowler. Mr. Harrison found, on putting them side by side, there were great discrepancies between them.

He quite agreed with the general proposition laid down, that a narrow-gauge line could be made more cheaply than a broad-gauge line. He did not think any one would, for a moment, dispute that; but the question arose, what was the extent of that economy? The estimates gave the saving in each item per mile. The first item was land,—Mr. Hawkshaw, £10, and Mr. Fowler, nothing. The next, earthwork,—Mr. Hawkshaw, £100; Mr. Fowler, £37: then bridges,—Mr. Hawkshaw, £50; Mr. Fowler, £83: sleepers and ballast,—Mr. Hawkshaw, £200; Mr. Fowler, £500. Total: Mr. Hawkshaw, £360; Mr. Fowler, £620; Mr. Fowler being £260 in excess of Mr. Hawkshaw. When a document exhibited so great a discrepancy in the estimates of gentlemen of such high position, the natural inquiry was, why did this discrepancy exist? Mr. Harrison had endeavoured, from such information as he had been able to obtain, to arrive at an analysis of that discrepancy.

In the first place, he took the item of land, which Mr. Hawkshaw put at £10, and Mr. Fowler, at nothing; and he concluded that the Author assumed that to be an omission, as he added £10 to

Mr. Fowler's estimate afterwards; but the whole extent was a question of a quarter of an acre of land per mile—strictly, it was 0·27 acre per mile—and the question was, what was the value of an acre of land in India? He saw from a report by Major Bonus, in his estimate of the land for the Indus Valley line, that the maximum value he attached to the land was 27 rupees per acre. Then the value of a quarter of an acre would be 13*s.* 6*d.*

That, Mr. Harrison fancied, was one of those items which might, without difficulty, be reduced to something like a certainty. As regarded the earthwork, if the additional width of 2 ft. 3 in., the difference between the mètre gauge and the 5 ft. 6 in. gauge, was taken as the basis of the calculation, the total amount was equal to 440 cubic yards of earthwork per mile of road a foot in height; and he was told that the average cost of earthwork was 5 rupees per 1,000 ft., or equal to £7 7*s.* for every foot-height per mile; and, taking an average height of 5 ft. for a cheap line, the cost would be £36 15*s.*, or, practically, what Mr. Fowler had put it at. Still, there were elements by which such a calculation could be accurately made.

On the subject of the bridges he had no means of judging whether Mr. Hawkshaw's £50, or Mr. Fowler's £83, per mile was right. All he would say was, in making the design for girder bridges which might be used on a light line of railway, of the standard gauge, he should be disposed to err on the right side, by making them stronger than calculating the minimum loads they had to carry: therefore, on that ground, he should take the higher of the two values.

When he came to the question of sleepers and ballast, there was a discrepancy of 150 per cent. between Mr. Hawkshaw and Mr. Fowler. Now he had analysed the basis on which Mr. Fowler made his estimate, and it was quite clear on the face of it, on making the comparison between the narrow gauge and the broad guage, how that difference arose. On the question of sleepers, which formed the most important item, Mr. Fowler took the section of the sleeper for the mètre gauge, at 8 in. by 4 in.; whereas, when he took the section for the broad gauge, he made that section 9 in. by 4½ in.

Now it was proposed that the weight of the rails should be the same in both cases, which meant that the loads that were to traverse them were the same also; and Mr. Harrison had yet to learn why, as the load was the same, and the rails were the same, the sectional area of the sleepers was to be different. He had laid thousands of sleepers of the section of 8 in. by 4 in. on a 4 ft. 8½ in. gauge, forty

years ago on one of the earliest lines. All the sleepers on that line were of that sectional area, the weight of rails was 40 lbs. per yard, and over a portion of that line the traffic between England and Scotland ran for about four years. Therefore, if the sectional area of 8 in. by 4 in. was sufficient for a gauge of 3 ft. 6 in., he had no hesitation in saying it was sufficient for a gauge of 5 ft. 6 in. with the same weight of rail and of passing load. But the difference in sectional area of the sleepers adopted by Mr. Fowler, caused a difference in his estimate of £150 per mile.

Then, again, on the question of ballast, Mr. Fowler took the depth of the ballast for the mètre gauge at 1 ft., but for the 5 ft. 6 in. gauge he took a depth of 1 ft. 3 in. If 1 ft. depth of ballast was sufficient for the mètre gauge, it was sufficient for the 5 ft. 6 in. gauge; therefore, that was a point on which he joined issue with Mr. Fowler, as to whether in that item a fair comparison had been made between the two gauges, and, if not, it made a difference of £81 per mile.

Then Mr. Fowler took an addition of £10 per mile for laying the additional gauge. What it might exactly be Mr. Harrison could not say, but he should put it at not more than £2 per mile or £3 per mile at the outside, because, in the manipulation of the laying of the rails, the only additional cost was connected with the handling of the larger sized sleeper. Mr. Fowler took the difference in sidings at 10 per cent., and said, if the main line cost a given sum per mile more than the mètre gauge, and all the sidings were the same, they must add so much to the cost per mile. In that, Mr. Harrison entirely agreed; but putting the whole together the result was only £378 per mile, instead of £633 per mile, as stated by Mr. Fowler. Mr. Harrison could not help feeling, that when the Author added together the two sums, of Mr. Hawkshaw's estimate, and of Mr. Fowler's estimate, with the addition of £10 for land, and then took an average of the whole, such a mode of making an estimate hardly commended itself as a proper mode of determining a question of such vital importance to our vast Indian empire. To take the average of two opinions, without a strict investigation of the mode by which those opinions were arrived at, reminded him of the mode he had often seen followed by common juries who assessed the value of land—they took the sum of the amounts given by the witnesses, and took an average of the whole. Now, taking the average, which was £497, as arrived at by the Author, there was added to that, for engineering and agencies, 17½ per cent., or £87 per mile. Mr. Harrison believed that, on many Indian railways, the cost upon the outlay

for works for engineering and agencies was that amount; but when the nature of this excess was examined, there were many items which formed that excess which could not for a moment come under the category of works which required an average of the whole of that expenditure. He took the engineering, the setting out of the line, the preparation of plans, the estimate of all the works, which were important items, and it was quite clear these would be expenses per mile equally chargeable upon the narrow gauge and upon the broad gauge, and, therefore, when he saw 17½ per cent. charged as an average of the whole cost, it was clear there ought to be a large deduction made from that item.

Then there was a question of saving of maintenance, which was put at £10 per mile, and capitalised at twenty years' purchase as £200. That, in itself, he did not at all find fault with, but he doubted very much whether the effect of the mode in which it was put was not calculated rather to mislead. It was not expenditure. It was quite clear, that to maintain the sleepers and other works upon the broader gauge, there would be a larger expense in renewals. He did not quarrel with the amount of £10 per mile, but he did not think, when they estimated what the outlay would be, this should be regarded as additional cost.

Then Mr. Hawkshaw had put in his estimate an item of possible saving of £200 per mile for curves. Now Mr. Hawkshaw admitted, not only with regard to that item, but with regard to other items of his estimate, that he had placed them at an amount which he believed would place it beyond the power of cavil; but Mr. Harrison was afraid he should cavil very greatly at this estimate of £200 per mile for curves. He did not know exactly what the nature of the country was, but he was told, that as a rule, sharp curves were not required, yet this was a charge which was proposed to be made applicable, not to special cases, but to the whole of the proposed 10,000 miles of railway throughout India. Now, surely, apart from the question whether £200 per mile was the exact sum, it could not be right—where they had the great majority of the lines, as he was told, through a country in which few or no curves were required—to apply the result of the special cases, and those quite exceptional, to the whole length of lines they were proposing to construct. He further took exception to the question of the saving alleged to be obtainable by the use of sharper curves on the mètre gauge; because, as he understood, there was a limit of 5 chains radius on the mètre gauge, and there was no difficulty whatever in adopting, for such lines, curves of 8 chains radius with the broad gauge. He had such curves at work with-

out the slightest difficulty over many miles of railway and very steep gradients. He had occasion some time ago to examine into this question as to the saving which could be effected by adopting sharp curves. To accurately arrive at the amount, it was necessary to go one step further by taking the additional length of line which the use of sharp curves entailed, and the cost of maintaining and working that additional line, and also to capitalise that additional cost. It would further be necessary to take into account that in many cases the apparent saving, which was solely a question of excavation, was far more than swallowed up if the correct plan was adopted of taking into account the increased cost of making, working, and maintaining the additional length of line: therefore he doubted whether in any case there could be an excess of expenditure of £200 per mile; and under no possible circumstances could such an expenditure be applied to the whole 10,000 miles to be constructed in India.

These items altogether brought up the cost, as given in the Paper, to £1,000 per mile. Now he begged to say distinctly from his own practical experience, if he were going to construct, in England, a mètre-gauge line, as compared with a light broad-gauge line, it would not save £400 a mile; therefore he entirely doubted the accuracy of the basis as set forth in the Paper, and on which, as he understood, the Indian Government had decided to introduce the mètre gauge. Whether the reduction from £1,000 per mile to £400 per mile would alter their ideas or not he could not say, but the whole basis of the Governmental decision, as put forth from the beginning to the end of the Paper, was stated to be that the one solitary reason for adopting a narrow gauge was a belief in its superior economy. It did not state the extent of that economy, but simply that it was a superior economy.

With regard to cheap lines, there were other circumstances beyond the mere question of permanent way which entered into the construction of cheap lines. He had, within the last three years, to make a line in Yorkshire—the Selby and York railway. That line was constructed on the first-class gradient of 1 in 240; but the contractor, happening to find a good brick-field in the centre of the line, laid down, for his own purposes, a permanent way of nearly the whole length of the line. The cuttings were from 18 ft. to 20 ft., and the embankments about the same height. During the whole progress of the line for two years this contractor's permanent way was laid upon the surface, and Mr. Harrison had traveled over it at a speed of 20 miles per hour. He was satisfied that if more attention was devoted to the use, in certain

cases, of short and sharp gradients, and in that way getting over the surface, a greater economy would result than was involved in the question of lightness of railway.

So far, then, as to the general question of economy: but now he would take up that which was put forward in the Paper as being by far the most important part of the question, namely, the applicability of the mètre gauge to the Punjâb system of railways—not only of the introduction of the mètre gauge, but of the mixed gauge, and of break of gauge. The Paper stated the proposal was to lay down a third rail in the 214 miles of line, from Lahore to Mooltan. That was a proposal to introduce into a portion of the Indian railways - which was admitted, in the Paper itself, to be one of the most important for strategic purposes—that break of gauge and of mixed gauge, which, in England, he was happy to say, were on the point of being abolished. He had been to a great extent connected incidentally with these questions of break of gauge, and of mixed gauge, and he had always heard from those interested—in South Wales particularly—the break of gauge described as the "curse of the district;" and when lately in South Wales he had heard equal rejoicings that a change had taken place. One gentleman connected with copper-works in Wales told him that the change of system by which the copper ore was taken directly to the works, had resulted in an economy of £1,000 per annum, and that additional income was derived entirely from avoiding loss in copper ore from transhipment.

The saving as between the mètre gauge and the standard gauge, as estimated by Mr. Fowler, was £680,000; but if the views which Mr. Harrison had expressed were at all correct, and he presumed Mr. Fowler had based his estimate on the same basis as his report, that amount would be reduced to a very large extent. It was admitted that there were sets-off to the extent of £327,177 for altering the existing gauge in one case, and for laying down the third rail upon 214 miles of the Lahore railway. Then there was a further item of £320,700 for rolling-stock for through-traffic, the extra narrow-gauge stock, and for military contingencies. Now that item was vouched for, according to the Paper, as necessary by General Strachey, Colonel Dickson, Mr. Fowler, Mr. Lee Smith, and Mr. Rendel; but it was argued by the Author "that not the smallest deduction on this account ought to be allowed." Now, in this case, he would bring to bear that which had been his own experience in these matters, and here he would quote the words of the Paper:

"Considering, first, the section from Mooltan to Lahore, the

existing quantity of broad-gauge rolling-stock thereon either is sufficient for all expected traffic, whether through, or local, or it is not. If it is not, then, in case the broad gauge had been adopted for the adjoining sections also, it would have been indispensable to provide additional broad-gauge rolling stock for the Mooltan-Làhore section; the cost of which addition would certainly have been at least equal to that of the quantity of mètre-gauge stock requisite in order to render the total amount of rolling stock, broad and narrow, capable of conveying all the traffic on a mixed gauge."[1]

Then the converse of that proposition was also gone into, and the same argument was also used as to the Lahore and Peshawur railway. Now, wherever two systems of gauge were adopted, the merest tyro in railway management would be aware that it was impossible to do the work with the same amount of stock which was required for an uniform gauge. He did not state this as a matter of opinion, but as a matter of fact, which he was satisfied every railway manager knew to be beyond dispute; but the Author asserted—on what authority was not stated—that not the smallest deduction should be made on that ground. There were many practical instances of it. He would take as an illustration the case of two collieries, each of which thought it was desirable to have their own particular stock; but if the railway company did the work, the stock with which they could do it would be less than the aggregate stock of those collieries. If, on the other hand, the railway company determined to carry a particular portion of their traffic by a particular class of wagons, and the other portion by another class of wagons, it was clear that, to carry that traffic, they must have a larger amount of stock. Then, again, there was the question of the expense of working. When they had the two systems to work, it was utterly impossible they could work those systems by running only the same amount of mileage. They had the mixed gauge; they had two sets of trains, one for the broad gauge, and the other for the narrow gauge; and, in working, they must have a largely increased mileage; thus the fair basis of calculation would be to take that additional mileage as an annual cost, and to capitalise it as a set-off. But that was not done.

Then, again, he did not see anything put down for the increased cost of maintaining the 214 miles of mixed gauge. No one could dispute the fact that there was a large additional cost in maintaining a mixed gauge. He knew that, when the mixed gauge

[1] *Vide* ante, p. 11.

was taken up, on the line at Oxford, the Great Western Company calculated they saved nearly £100 per mile in maintenance of way; and he knew the saving could not be less than a fourth of the cost of maintaining a single gauge; and if that was put at £80 per mile, the increase of £20 per mile—which was the minimum—and capitalized that amount per mile over 200 miles, it would be found there was an amount of £80,000, as a set-off against this £320,700. Then he saw also, at the other end of the line, the whole of the stock of the Scinde railway would be thrown upon the hands of that company, and it must be sold. That line was now of the standard gauge, and that being done away with, they would have that stock to sell, and to supply its place with other stock. He saw no account of the loss which would be sustained by that; and it was well known if a company had stock to sell they would think themselves happy if they realized anything like 50 per cent. of the first cost. If he took all the items together, the conclusion he arrived at was that, so far from this crucial test, the one solitary reason, superior economy, being actually realized, he, on the contrary, had no hesitation in stating that the adoption of this mètre gauge on the Punjâb system of railways would be found to occasion actual and positive increased cost to the Indian Government.

Now there was one other point which he thought had not yet been sufficiently tested anywhere—certainly not in England—and that was, what would be the actual cost of working this mètre gauge. The only instance in England was the Festiniog railway, which he knew and had traveled over, and there the expense of working and maintenance came out at £1,000 per mile. Now, he knew perfectly well that for years the Newcastle and Carlisle line, with a traffic greater than that of the Festiniog railway, never exceeded £500 per mile. What was it in this gauge that caused the Festiniog line to be worked at a cost of £1,000 per mile? He thought that, before assuming as a fact that there was to be this great saving in cost, when the Government were going to adopt an innovation affecting the whole of India, it would be a prudent plan to ascertain with more certainty that which was not referred to in the Paper, namely, whether in the actual working there was any saving at all, and whether there might not be a loss? He held that was a point which was already settled, taking the results at Festiniog as a guide. He was reminded that the Festiniog line was only of 2 ft. gauge. That was true; but the argument had been used, that if a line of 3 ft. 3⅜ in. gauge could be worked more cheaply than a line of 5 ft. 6 in. gauge, then by reducing the gauge to 2 ft. it

would be worked more cheaply still; but he believed the reverse would be found to be the case in working.

There were several other points to which he should have been glad to refer; because he found they were matters in which, in a practical point of view, he considered that the assumptions in the Paper were entirely erroneous. But he felt he had trespassed sufficiently long upon the time of the meeting, and many other speakers would be able to go into those matters and to elucidate them.

Mr. J. HAWKSHAW, Past-President, said the Paper referred to a former report of his, and, in fact, professed to draw from that report, to a certain extent, the data which led the Author to the conclusions he had stated. But on looking at the Paper and comparing it with his report, from which it purported to make extracts, he had been a good deal puzzled to make out the figures which had been ultimately put forward by the Author.

It purported to deal with averages of figures given by himself, and with certain figures given by Mr. Fowler, in a report made three or four months later; but he could not discover how the conclusions arrived at could be derived from those figures. In his report, Mr. Hawkshaw had nowhere put the saving of the 3 ft. 6 in. gauge at a greater sum than £760 per mile; and Mr. Fowler put that saving in one case—that of the Kotree and Mooltan line—at £866, and in that of the Indus and Peshawur line, at £794; and the average of these two was £830 per mile. If they took these figures, £830 per mile and £760 per mile, they got an average saving, so far, of £795 per mile; and that was the only result he could find from averaging Mr. Fowler's figures and his own. But in that £760 per mile was included a sum of £200 for saving of locomotives. Now although Mr. Hawkshaw had included that sum in an aggregate, yet he stated, for reasons which he gave, that he thought it had no business to be there; and if that £200 was omitted—and the Author seemed to think that it should be omitted—then the average saving derived from his report and Mr. Fowler's report came only to £695 per mile. So far, therefore, if the Author had followed those figures, he would have got only a sum of £695 per mile, instead of £1,000 per mile.

With regard to his own report, it was made entirely for the Eastern Bengal Railway Company, and solely had reference to whether they could judiciously make an extension of that railway on the narrow gauge, instead of on the existing gauge. In making that report he put forward the fullest possible saving that could be arrived at by adopting a narrow gauge; and he now thought he

put the items of saving too high. He agreed with Mr. Harrison, that the assumed saving of £200 on curves would never be realised. He could also quite agree with Mr. Harrison, that they never would in India, by adopting the mètre gauge, effect a saving of more than £400 per mile or £500 per mile—possibly not more than £400 per mile. So much for the saving. But there were serious items on the other side of the account. In this country it was well known what those items meant; for that was a very old question, discussed thirty years ago, and which some persons reasoned upon then, as the Author did now; and what were the results? The results had been that those who said the evils of this break of gauge would be too serious to be borne proved to be right; and that those who said they were little and trifling, as some gentlemen then said, had been proved by experience to be quite wrong. The Author said it was admitted—on what authority was not stated—that the money value, in a commercial sense, of a break of gauge was *4d.* per ton. He need only say, to gentlemen who were acquainted with this subject, that the Author ought not to have stated that any such thing was admitted. In fact, nothing could be more erroneous. Possibly the Author might have got that figure from Mr. Hawkshaw's report; for, in referring to the evils of this change of gauge, and alluding to what occurred thirty years ago, he stated that the commercial inconvenience had been estimated at from *4d.* to *8d.* and *1s.* per ton; but then he went on to say, that experience had shown those estimates to be quite fallacious.

Then the Author measured this question in another way. He dealt with the present income of Indian railways, and said they now only made 3 per cent.; and he seemed to infer, because they only made 3 per cent., they were only carrying three-fifths of the traffic they were intended to carry; and therefore the mètre gauge could carry that amount, &c. Now, an argument of that sort, applied to Indian railways, would mislead. He remembered the time when the Lancashire and Yorkshire railway earned only 2½ per cent.; that company was now about to declare a dividend of 9¼ per cent. By parity of reasoning, men living at that day might have said, "This gauge is altogether wrong: you gentlemen do not know what you are about. You are making only 2½ per cent., and you ought to have had a gauge of 2 ft. 9 in." But there was an item which the Author overlooked with regard to the Indian empire, and with regard to the question of dividend. He believed it could be clearly proved that every nation gained as much from every railway that was made as the

proprietors gained—nay, he believed it gained much more. He had occasion about the year 1850, at the time the Lancashire and Yorkshire railway was earning only 2½ per cent., to go before a Committee of the House of Commons to advocate a Bill which proposed to increase the tolls, which they thought were too low. The Board of Trade reported against the increase, which was natural; but he thought he satisfied the Committee that, though the Railway Company was only earning 2½ per cent., the districts through which the railway ran were receiving more than that percentage on the capital which had been expended in making the railway. Therefore he must maintain that it was a grievous error in advising those gentlemen who had the control of affairs in India in coming to conclusions as to the extension of railways, to negative the advantages to the country through which they passed. He believed that the gain to India, from the railways, would probably be nearly double the dividend which they afforded to the railway proprietors.

There was another point on which he laid great stress, but of which the Author appeared to think lightly, namely, the questions of the gauge and of the character of the railway, in a strategic point of view. He should not have ventured to have spoken on that branch of the subject had he not, with others, had occasion, at the request of the War Office, to advise as to the means of moving troops in Great Britain by means of the existing railways. They then learnt the difficulty of the task. He thought it of vast importance to a country like India—even more important than to Great Britain—that they should be able to pass troops by railway with the least possible obstruction; but the Author said there would always be ample notice of an invasion of India, and that there would be opportunity for proceeding "with the most complete deliberation" in massing troops at some particular place there to await the invaders. Suppose that the invaders did give notice they were coming, and that the British Government had time to get troops to a certain point with deliberation —if the troops were to be kept waiting at that spot, he should like to know what the expense of that would be? But besides an invasion, might there not also be another Indian mutiny, to put down which the troops might have, at an hour's notice, to be carried with the utmost rapidity to another point? Therefore one effect of this broken network of railways in India must be to delay transport, and to add to the confusion, always too great, in such cases, under the most favourable circumstances; this, in his opinion, apart from all commercial questions, might render the proposal

now made, if persisted in, one of the greatest calamities that could be brought upon the country. At all events, he would say, do not proceed with this great "programme," as the Author called it, of making 10,000 miles of mètre gauge, without a thorough and efficient inquiry. Let those gentlemen who supported this measure go before some committee or commission, capable of understanding and of testing their statements. To arrive at a decision without some such previous step, would be, in his opinion, one of the most unusual proceedings that he could imagine in any country. He would not then make any further observations, because some of the remarks he had made had already appeared in his report. He would only add that, neither personally nor professionally, had he any interest in the question of what gauge was adopted in India. He, however, conceived that a most unwise and crude scheme had been suddenly propounded, without due consideration, and that if the Government persisted in carrying it into execution, it would be a consummate act of folly.

Mr. G. P. Bidder, Past-President, said that, being the Consulting Engineer of that particular section of railways in India which had been the first assaulted by this scheme, he had taken, as might be imagined, particular interest in it; in point of fact, he believed he was the first Engineer whose attention was drawn to the project of the introduction of the 3 ft. 6 in. gauge into India. He was called upon by the Directors of the Scinde, Punjâb, and Delhi railways to report his opinion of the probable consequences of such an introduction, and on the 14th of June, 1870, he made his report, in which he did not enter into such details as Mr. Hawkshaw and Mr. Fowler had done, but he stated in general terms that he knew there could not be any saving by the introduction of the exceptional gauge on the Indus Valley railway. He thought it was now necessary that a short statement should be made of the mode in which this question had been introduced in this country by the Indian authorities. Soon after his report had been made to the Scinde Railway Company, another report was obtained from Mr. Hawkshaw; and then a Commission was appointed—and he would use a strong word—a packed Commission, with a Duke for a dry nurse, to proceed to Norway in one of Her Majesty's yachts to inspect a railway in that country. The Commission went to see a railway, of a narrow gauge, and a more common-place railway it was impossible to find. He knew it very well, and he was an unfortunate shareholder in it; and he only wished that it could be made to pay a dividend; but he did not attribute its non-paying character to the gauge. The railway in question had never yielded any

dividend, and he doubted whether it really paid the working expenses; whereas a railway of the ordinary 4 ft. 8½ in. gauge, with which he was also connected, in the same country, paid a dividend of from 5 per cent. to 6 per cent. per annum. If this Commission, to which he had alluded, instead of going to Norway had gone to the West India Docks, and had seen some contractor's engines at their ordinary work there, or had gone to a colliery which could have been pointed out to them, where they would have been shown a 4 ft. gauge altered to the standard gauge of 4 ft. 8½ in., to obviate the inconvenience and expense resulting from a break of gauge, they would have derived more practical experience than they did from their pleasant trip to Norway.[1] Before quitting the question of exceptionally narrow-gauge railways, he would allude to the Festiniog railway, which was stated to be paying a large dividend, which was mainly assigned to the fact of its being constructed on the narrow-gauge system; whereas, the most superficial inspection of the line would show that the dividend arose entirely from the exceptional character of the traffic—slates packed in conveniently small carriages, traveling down a good working incline to the shipping port, and paying a most unusual rate of freight. These were circumstances rarely to be found combined in other localities.

Agreeing, as he did, with the general conclusions stated by Mr. Harrison and by Mr. Hawkshaw, he would not go over that ground again, but would address himself to the particular case in which he was more especially interested — the alleged economy in the introduction of this gauge for the Indus Valley railway. He was necessarily better acquainted with the condition of that part

[1] It is deserving of notice, that on the 7th of October, 1872, there was opened, in Norway, a line of 32¾ English miles in length, of a gauge of 3 ft. 6 in., between Christiania and the Port of Drammen. There were upon it some sharp gradients and curves, which required adequate engine power. The general result had been that the engines and the rolling stock had been found to be utterly insufficient. The weight drawn by each engine, its own weight not included, was only 652 cwt., as compared with 1,595 cwt. drawn by the engines on the 4 ft. 8½ in. gauge lines. The traffic had therefore of necessity been confined almost entirely to passengers. The speed attained was, for fast trains with 2 stoppages, 1 hour 40 minutes, or about 19 miles per hour; for ordinary trains with 8 stoppages, 2 hours 13 minutes, or about 14 miles per hour. Up to the present time very little merchandise could be transported. The general result was, that in deference to the public opinion, it had been enacted in the 'Storthing,' or Parliament, that for the future, the State Railways should only be constructed on the standard gauge of 4 ft. 8½ in.; and on that gauge the new State line, 126 English miles in length, *viâ* Frederikshald, to the Swedish frontier, now [illegible] be commenced, would be constructed.—G. P. B.

of the Empire, and his mind had been specially directed to various circumstances connected with it.

Now, assuming Mr. Hawkshaw's figures — £400 per mile, and adding £200 more for maintenance, which, as it was a reversionary value, did not begin for many years; but assuming the saving to be £600 per mile. The number of miles over which it extended was— 490 miles for the Indus Valley; and 270 miles for the Peshawur line; making 760 miles in the whole; and £600 per mile over that would represent £456,000. That was the whole advantage they claimed, and that was in construction. Now for the 'per contra' statement.

With regard to the Scinde railway, it was proposed to narrow the existing line. Mr. Fowler assumed the cost to be £500 per mile, equal to £53,000. Then, as Mr. Harrison stated the case, the whole of the rolling stock there must be sold, and must be transported up the Indus Valley to where the ordinary 5 ft. 6 in. gauge prevailed; but this transport must be 500 miles up the river, between Mooltan and Kotree. Now, as an example of what the cost of transport in India was, he might mention that the charge actually made by the East Indian railway, from Calcutta to Delhi, a distance of 1,000 miles, for hauling up engines and wagons, not in steam, but with the ordinary goods' trains, was £350 per engine and £50 per wagon; these charges upon 100 engines and 1,250 wagons, with other incidental expenses, made a total of more than £100,000 paid for railway conveyance.

Then, as to rolling stock, Mr. Harrison had stated the A B C experience of railway traffic. Assume a line broken up into sections, and that there was required a separate stock for each section, there must be a much larger stock than was necessary for working the section throughout, and that position applied more particularly in the Indus Valley, for he had considered the question of traffic, and had advised the Directors as to the cost of the railway and the amount of rolling stock that would be required.

The traffic of the Indus Valley at the present time was represented by steamers, making fortnightly journeys each way. Now speaking, as he was, in the presence of engineers who knew that the principal strain on the rails was due to high speed, he felt assured that they would agree with him, that a speed of 25 miles per hour on light rails of 40 lbs. to the yard, would admit of an ordinary locomotive engine traveling upon them, and as that would be quite adequate to the requirements of the Indus Valley traffic, the existing stock of locomotive engines need not be increased. He also came to the conclusion that, as at present, the wagons were detained at Mooltan and Kotree to be loaded and unloaded, and

as this must hereafter be, more or less, the case with a break of gauge, all of this would be avoided by a continuous route, and no additional stock would be required; thus the whole of Mr. Fowler's estimate, amounting to £400,000 for rolling stock on the Indus Valley, would be saved on this section of the line.

The next important saving would be effected in the rolling stock for the extension to Peshawur, as, in case of emergency, recourse might be had to that of the general system, and certainly more than one-half of the stock would be found sufficient; thus a further saving of £106,000 would be realised.

To this must be added the cost of a third rail from Mooltan to Lahore, estimated by Mr. Fowler at £275,000, and the amount of extra cost of maintenance, estimated by Mr. Harrison at £20 per mile capitalised.

Lastly, the extra cost of altering the Lahore station into an interchanging, in place of a through station. It was difficult to estimate this, but, assuredly, it could not cost less than £50,000.

By adding up all these items, namely:—

		£
1.	Altering the gauge on the Scinde railway	53,000
2.	Rolling stock on the Indus Valley	400,000
3.	Ditto on Peshawur extension, one half	106,000
4.	Laying third rail from Mooltan to Lahore	275,000
5.	Extra maintenance of ditto at £20 per mile capitalised	80,000
6.	Altering Lahore station	50,000
	A total was arrived at of	£964,000

Therefore he came to the conclusion that, instead of there being any economy, there would be an absolute additional expense in adopting the narrow gauge, and, therefore, the sole element for its justification was an entire failure in that respect.

Now as to the inconveniences of this proposed system—there was an expression made use of in the Paper which was remarkably applicable to the case. The Author, in referring to the invasion of India by the Russians, had used the expression, the "genius of folly." Mr. Bidder must be permitted to use this felicitous phrase, and to apply it to the introduction of this gauge without having previously ascertained the results; and when a gentleman of the Author's official position talked of *4d.* per ton as representing the commercial value of the break of gauge, he could not avoid saying that it was the "genius of folly." The Author, a man of great intelligence, living in London, must know that the break of gauge ... country had long been felt to be unendurable, and that the

change to an uniform gauge had been made at great expense. Had Sir Daniel Gooch or Mr. Grierson been asked why they made the change, they would have clearly shown the numerous and important evils inherent in the system, apart from the mere cost of transporting the goods from the narrow gauge to the wide gauge, and *vice versâ*, and, therefore, not to have inquired from them the reasons for incurring such cost and inconvenience on such a railway as the Great Western, before a statesman ventured to recommend so vital and detrimental a change in India, deserved to be stigmatized as the "genius of folly." Then the Author ventured on the assertion that it was necessary that the same engine should be used throughout any system of railway, whatever might be the variations in the strength of the rails. He could not possibly have traveled out of London by any of the main lines without seeing the engines changed at different parts of the journey, and at Crewe he would have seen three separate trains propelled by as many engines united into one train drawn by one engine. Even in the rural district of Devonshire he would find a branch railway where the broad-gauge wagons were propelled by a small 'contractor's engine.'

Mr. Bidder must take exception also to the spirit in which the Paper had been drawn up. He alluded to that part in which it was stated that the natives of India were taxed £1,600,000; that being the difference between the net receipts of the railways and the interest paid by the Government. That remark might apply to a great many things, no doubt, but to apply it to the railways of India was the "genius of folly." Was it no advantage to the people of India to be carried at greater speed and at less cost? Was that a tax upon them? Was the postal service no compensation? Was the greater efficiency of the army, and the means of moving that army more rapidly, no compensation? And yet the Author had characterised the difference between the net earnings of the railways and the interest paid on them as a total loss, and an unmitigated tax upon the natives of India. As if the money had been spent on a mere toy.

Now Mr. Bidder could tell them where the waste was, but this was not the proper place nor the proper occasion to do so at any great length. He would, however, give a few instances. The original financial arrangement for executing the Indian State railways, if not altered, was a rare specimen of the very "genius of folly." It was proposed to carry on all the new lines "pari passu," the works to be extended over a period of twenty years. Thus, assuming twenty millions sterling to represent the sum to be

expended, the outlay was to be at the rate of one million per annum. The first result would be, that for nearly the whole of that period, the capital would not only be unproductive, but the unfinished works would be a constant source of expense for maintenance, to say nothing of the waste from the decay of the wood and the iron. Besides which, the cost of supervision would be immensely aggravated, and all responsibility be lost by the lapse of time. There were two obvious alternatives, each much more rational. First, by commencing and completing the most important sections as soon as possible, by the concentration of all the resources of the engineering staff upon these works in the application of the outlay of one million per annum. Thus no more ultimate capital would be expended, and the lines, as they were finished, would be a source of convenience and possible profit, instead of being a cause of current outlay. Another plan, and that adapted to the meanest capacity, would be to invest ten millions sterling in the Indian Railway stocks at five per cent., reinvesting the annual income. Thus, in fourteen years, the ten millions would grow to twenty millions, and if judiciously applied would finish the lines by the end of twenty years as originally projected, whilst ten millions of money would be saved, being equal to the anticipated but illusive saving to be effected by introducing the narrow gauge in India.

It had been part of his duty to frame a contract for the construction of the Delhi railway. That was to some extent an experimental work. The line had to cross several very large Indian rivers, with regard to the special features of which no reliable and definite information could be obtained; they had to some extent to grope their way in the dark; and, in order to mitigate the risk to the Company, it was his desire to secure the skill and attention of the Contractors in aid of the work by making them liable for the maintenance of all the work, including the bridges, for a period of three years. The contract was sent out to India to be approved by the authorities there, and it came back with the remark, "The charge for maintenance, both as regards time and amount, is too great. Three years is unusual, and in such a climate two years even is excessive." No doubt, in the opinion and experience of the 'Reporter,' this was true; because the gentleman had never had any experience. He was like the Irish fiddler, who did not know whether he could play or not, because he had never tried. But in the case of the bridges which were injured by a flood, the shortening of the period of maintenance, from three years to one year, involved a loss of £200,000, which would have been entirely obviated by the pay-

ment, under the arrangement objected to, of a sum of £90,000, from which there would have been deducted the actual cost the Company had incurred for two years' maintenance of the rest of the line of, say 300 miles in length, which would have reduced it by a very substantial amount.

In another case, a gentleman in high position at Bombay, was directed to advise upon what economy could be effected in the working of the Indus flotilla. That was a mixed question of economy and commercial return; but what he had to look to had nothing to do with the convenience of the public or the commerce —the only thing to be considered was positive saving, and on that point, the report which was made, dated 1st April, 1870, stated:—

"There are no objections to Captain Wood continuing to dispatch boats from Kotree as soon as he has obtained a full cargo; but he should report whether it would not be expedient to make the filling of vessels with cargo the sole condition of departure instead of endeavouring to maintain a fortnightly service. The sooner it appears to Government, that the flotilla is reduced to a strictly commercial service, the better is the prospect of a remunerative return."

These were samples of the way in which these things were investigated in India, but he did not know that they could very well be avoided, because on the inauguration of the railway system the Indian Government enforced upon a very intelligent and able body of men conditions of service which it was impossible effectually to comply with. For instance, they took a military gentleman, who came probably from the building of a barrack, or a church, or some other useful employment, to try his hand at railways. The position was entirely new to him. He had to grope his way, and in time he obtained some practical knowledge; but on promotion he would be removed, and another officer came in his place; so that no responsibility could be fixed upon those gentlemen; and unless a man had an ample knowledge of every branch of engineering the result must necessarily be disappointing. Owing to these circumstances, a vast increase of expense had been thrown upon the Indian railways and the public works in general, which might have been avoided had a more efficient system been adopted.

On the question of this mètre gauge, a 3 ft. 6 in. gauge was first talked of, and was then suddenly altered into the mètre gauge, for what reason nobody had yet explained. The only reason that suggested itself was, that it had an appearance of science about it. It was very scientific to say, "This is the ten-millionth part

of the quadrant of the earth's circumference," and that might be the foundation for this arbitrary mètre gauge. All he had to say about it was that, apart from the question of rolling stock, the alleged saving in bridges, earthwork, and other construction, was altogether illusory. In order to obviate the objections to the narrow-gauge stock, as originally designed to meet the exigencies of military transport, the rolling stock, as now designed, was nearly, if not quite, as wide as that on the ordinary gauge. This at once disposed of a large part of the alleged saving; for, as this extra width could only be attained by making the frames overhang the rails 1 ft. 1½ in. more than at present, much more strain was thrown on the rails, and much more wear was occasioned to the wagons. The carriages themselves involved extra cost of maintenance, which it was impossible to estimate; in fact, the width of the formation of the excavations, as well as of the bridges, both over and under, could not, in practice, be reduced below that of the ordinary gauge; so that a similarity must exist in all particulars, save that of the mere width between the rails.

Mr. Bidder would now only ask the attention of the meeting to an extract from the last report, from the able pen of Mr. Juland Danvers, made in 1872:—

"A great deal has been said lately about the burthen thrown upon the Indian revenues by the railways, in consequence of their failure to earn the amount paid by Government for the guaranteed interest upon the capital. This result is no doubt greatly to be lamented, and is contrary to the expectations of those who advocated and sanctioned the existing system. But taking a broad view of the subject, these undertakings may claim, as a set-off against their shortcomings, credit for many direct and indirect benefits which they have produced.

"To say nothing of the moral and social improvements, which as civilizing agents, they have conferred on the country, there can be no doubt that railways have added to its security, have greatly advanced the material prosperity of the people, and have been the means of increasing the revenue and of saving much expenditure, both on account of the army and post-office. They are still in their infancy, and their direct contributions to the revenue are capable of expansion. Experience has taught us lessons, and we have paid for them; but I venture to think that there is more ground of hope for the future, than regret for the past. And as regards the present, difficulties and uncertainty should furnish a strong incentive to skilful administration and increased exertion."

With these words he entirely agreed; and he hoped the increase

in the prosperity of the Indian railways, and the advantages to the proprietors, would not be arrested by the proposed introduction of a break of gauge, which could only be characterised as a calamity, as grievous, with regard to railways in India, as it had been in this country.[1]

Major-General STRACHEY, R.E., F.R.S.—being unable, on account of hoarseness, to make himself audible—handed in the following written remarks, which, by permission of the President, were read by the Secretary. He stated that he came forward in this discussion with some hesitation, and, perhaps, even with some anxiety. He felt that he appeared under great disadvantage in following some of the leaders of the Engineering profession, men whose adverse opinion necessarily carried with it great weight; and that he was addressing an audience, the sympathies of the majority of which were with his opponents. He was there, having no authority to represent the views of the Government, whose acts were in substance under discussion, but with the sense that any failure on his part to carry conviction would be attributed, not, as it should be, to his personal deficiencies, but to the cause itself. However, he was conscious that, under the circumstances of the case, it had become necessary for him to take a share in the discussion, and he accordingly did so.

---

[1] Since the conclusion of the discussion it has been ascertained that on the 11th of March, 1873, a return was made to the House of Commons, signed by Mr. Thornton, containing the following extract from a Minute of the late Lord Dalhousie respecting the gauge of Indian railways:—

"Extract Minute by the Earl of Dalhousie, Governor-General of India, dated 4th July, 1850.

"32. The Court of Directors have recommended, at the same time, the use of the narrow gauge of 4 feet 8½ inches for the railway about to be constructed. Although the letter of the Court recommends, but leaves to the Government of India to determine as to the gauge which should be adopted on this occasion, I consider the question to be one of such moment as to deserve a careful consideration and an authoritative and conclusive decision by the highest authority connected with the Indian Empire, who alone can have access to that full information and extended experience which would make such a decision really and satisfactorily conclusive.

"33. The British Legislature fell unconsciously, and perhaps unavoidably, into the mischievous error of permitting the introduction of two gauges into the United Kingdom. The numerous and grievous evils which arose from that permission are well known, and will long be felt throughout all England. The Government of India has it in its power, and no doubt will carefully provide, that however widely the railway system may be extended in this Empire in the time to come, these great evils shall be averted, and that uniformity of gauge shall be rigidly enforced from the first."—*Vide* Appendix I.

Before proceeding to the more special matter in hand, he would say a few words as to the manner in which the question before the Meeting had been treated by the gentlemen who had preceded him. They had, as it appeared to him, spoken, if not with an expressed, at all events with an implied sentiment, that the Government of India should submit itself to the judgment of the Institution, or of English engineers, in respect to the course it had taken in adopting the narrow gauge in India. There had been a sort of assumption that English civil engineers were, in such a question as that before the Meeting, the fit persons not only to advise but to determine, and that engineering experience obtained in England was the only qualification of any value in dealing with the details under discussion. There had been no indication that other considerations were involved in the policy of the Government than those of a technical nature. There had been no recognition that the circumstances of India had any important bearing on the questions at issue. There had been no suggestion that persons who had passed a large part of their lives in India might be better able to judge of the wants and capabilities of that country, than those who had never even seen it. There had been no account taken of the probability that those who were responsible for the government of that country, and who alone could have at their command all the various available sources of information regarding its political, social, material, and financial condition, must be the proper persons to decide such a question as this; and that it would be a complete inversion of parts for the Government to supply its general knowledge to professional critics, and to leave to them the guidance of its policy.

He felt the highest respect for the judgment of the leading civil engineers of this country, and he assented to a large part of what had been said in the discussion by Mr. Harrison and by Mr. Hawkshaw; but he could not admit the necessary applicability of many of their doctrines to every case; and as regarded the present case he denied the applicability of much that had been said. He must affirm, as a general principle, applying to all branches of the gauge discussion, that experience based on one set of conditions was not conclusive under totally different conditions. In truth, the correct presumption, where conditions differed greatly, was, that results would also differ greatly. When, therefore, the Government of India and its advisers were more or less directly charged with want of due regard to professional considerations, based on English experience, he did not hesitate to retort, that, whatever might be the technical knowledge of the critics, they

did not possess such a knowledge of Indian local conditions, or of the practical administration of a great country, as to render their opinion more than one of the elements—though an important one—in the consideration of the question. Further, he was convinced that the serious financial failure of the Indian railway system—for that it had failed financially was beyond question—had been caused by the want of subordination of European technical skill to a proper perception of local wants and resources; and the lesson that he necessarily drew from that conviction was, that the progress of railway construction in India should be brought much more completely under the control of the responsible government of the country than had hitherto been the case.

The Government of India had thus summed up the grounds on which it had resolved to adopt the narrow gauge for the railways between Lahore and Peshawur, and Mooltan and Kotree:—"We are satisfied that the economy likely to be obtained from the adoption of the narrow gauge will justify our accepting the break of gauge at Lahore, with such inconveniences as it involves." This, he believed, quite fairly stated the case. That certain inconveniences might be caused by a break of gauge was not denied, but the advantage to be secured, by economy of construction was said to be such as to justify the conclusion come to.

The Paper under discussion had for its object the elucidation, from the Author's point of view, of the facts on which such a conclusion might be supported. The reply that had been given to the Author, by the gentlemen who had already taken part in the discussion, had been directed to the object of showing that on the Author's data the saving of money by the adoption of the narrow gauge would not by any means amount to what had been represented in the Paper, and, in fact, that it would be insignificant; while the objections to the break of gauge were little short of insuperable.

Now he would at once recognise that the Author's adversaries had, at all events, some appearance of success in their criticism of the first part of the Author's argument; namely, that which related to the supposed superior economy of the narrow-gauge system. But this advantage was not substantial, and, so far as it had gone, had been gained over the Author's way of stating his case, and in no way disturbed the essential conclusion affirmed by the Government of India.

Before going on to state the grounds on which he rested this remark, he thought it would be desirable for him to show what was likely to be required of an Indian narrow-gauge railway, and

to what extent it would be able to meet those requirements. If the mètre-gauge lines, as now being constructed, were not fully able to carry all the traffic likely to be brought upon them, the whole argument in their favour would be at an end; but he would show how questions on that point might be met.

It had been ascertained that the total traffic of the East Indian railway, the heaviest worked line in India, might be taken to be about equal to 840 tons of goods, and 1,064 passengers, carried over every mile of railway in 24 hours. Also, it had been found that, taking the combined passenger traffic and goods traffic, the average load of an East Indian train was about 71 tons of goods, together with 89 passengers, which, for the present argument, might be considered as carried in a mixed train.

Supposing, further, the passengers to be equally divided between the up and down traffic, and the goods to be carried in the approximate proportion that actually held in the two directions, about 6 trains, such as he had described, in both directions, would suffice to do the work.

Now if a narrow-gauge railway, such as those actually under construction at the present time in India, were set to carry this traffic, it would be found that the load of an average East Indian train could be conveyed in about 14 narrow-gauge wagons and 3 narrow-gauge passenger carriages, of the pattern now being supplied—that was supposing all the wagons and carriages to be run full. If the vehicles were supposed to carry only half their full loads, double the number of such trains would be required to that actually run on the East Indian line. Such a narrow-gauge train as he was speaking of would consist of, say, 18 vehicles, including a brake-van, and, if full, might weigh in the gross 144 tons. With vehicles half full the load might be about 100 tons. One of the 12-ton engines recently made for the Indian narrow-gauge lines would suffice to draw such loads on the ordinary easy gradients of Indian lines.

Hence it followed that the whole traffic of the East Indian railway, as now existing, might be carried on a line of narrow-gauge railway, with an average of 12 trains a day each way, such trains running half empty. As such a condition of things could not possibly be necessary, and as 2 engines could be combined, or 18-ton engines and 24-ton engines could easily be provided if desired, there could be no room to doubt that the narrow-gauge lines, as now being constructed, and doubled when necessary, were quite capable of carrying the heaviest traffic now existing in India, or ever likely to be brought on them.

The narrow-gauge wagons and passenger vehicles were quite able to carry what was required, whether merchandise, or military equipments, or stores—the heaviest siège gun with its carriage did not weigh 5 tons—or that was or could be carried on the 5 ft. 6 in. gauge; and the only real difference between the gauges in that respect was, that more vehicles were required on the narrow gauge than on the broad gauge, to contain a given weight of goods. Under these circumstances it seemed quite opposed to fact to speak of the mètre-gauge lines as 'toy' railways, or as being weak with reference to the actual traffic to be carried on them.

Having, as he believed, thus fully established the sufficiency of the narrow-gauge lines under construction for all that was required of them, he would discuss the question of their cost as compared with that of broad-gauge lines.

It was first essential to inquire whether the estimates, that had up to the present stage of the discussion been referred to, properly represented the cost of the railways that would have been constructed between Lahore and Peshawur, and between Kotree and Mooltan, if, on the one hand, the narrow gauge had been adopted, and on the other, if it had not. To this inquiry only one answer could be given, namely, that those estimates were utterly worthless for the object in view; that they did not in any way represent the financial consequences of the alternative systems of construction, and that the conclusions of the Government of India were not based upon them or anything like them.

The Author, giving what might be termed a logical turn to his argument, had endeavoured, and General Strachey thought with complete success, to show that even on the figures which had been put forward by the opponents of the narrow gauge in the present case, an important pecuniary gain would have been secured by the adoption of the narrow gauge. Rejecting those figures as wholly inapplicable, General Strachey asserted that the financial advantage, that had in fact been secured, was very great, and that it would fully justify the conclusion that had been come to by the Indian Government.

The estimates referred to were based on a 40 lbs. rail for the narrow gauge, and a 42 lbs. rail or a 45 lbs. rail for the broad gauge, and, so far as he could judge, corresponding loads for the bridges, thereby implying that the alternatives between which the Government had really made a selection, were lines thus to be designed. He denied this emphatically. It was certain as a matter of fact, which he challenged any one to disprove, or even to question with a show of reason, that if the broad gauge had been adopted the rails

would not have been lighter than 60 lbs. to the yard, and that the general characteristics of the lines and the stock, engines, as well as vehicles, in use on the neighbouring broad-gauge lines would also have been accepted, and that all the bridges would have been designed to carry the heavy loads of that gauge, instead of the reduced loads of the narrow gauge.

He was at the present moment stating what would have been, as distinguished from what might have been, and he positively asserted that the question which the Government of India had to decide was this:—"Shall we accept a narrow gauge with all possible economy, subject to such inconveniences as a break of gauge at Lahore involves; or shall we preserve the continuity of gauge, and provide for the free passage of the stock of the existing broad-gauge railways to meet possible military exigencies, by the adoption of the broad gauge in its existing form for the lines to be made on the Punjâb frontier?" The idea of a compromise between the two plans which should give some of the advantages, while it had some of the disadvantages of both, did not appear to meet the real question at issue, and did not come seriously under the consideration of the Government.

As a fact the construction of the Lahore and Peshawur line had actually been begun on the broad gauge before the question of adopting the narrow gauge was raised, and 100 miles of 60 lbs. rails were ordered, and the original designs of the bridges were prepared on the regular broad-gauge standard of strength.

For these reasons it seemed to him to be placed beyond dispute, that the actual saving that would be obtained, by the adoption of the narrow gauge in the Punjâb, could not be reckoned at a smaller sum than from £1,000 to £1,500 per mile on account of permanent way, and from 30 per cent. to 40 per cent. on the cost of the iron-work of all bridges, besides minor economies of various sorts, into which it was needless to enter in detail.

For the Lahore and Peshawur line, on a length of 270 miles, the saving on permanent way would amount to about £350,000, and on the bridges perhaps to £250,000, or together £600,000. On the whole he considered that the total economy might be about three-quarters of a million. The 490 miles of the Indus Valley railway would give a saving of not less than £500,000 on the permanent way, and probably as much more on other items, or, in all, about one million; but the character of the works was not yet sufficiently known to admit of any very precise statement being made as to this line.

Against the savings thus attainable must be set off the cost of

the first change from the broad gauge to the narrow gauge on the line between Lahore and Peshawur, and the outlay necessary for obviating a break of gauge between the new narrow-gauge lines and the existing broad-gauge lines from Kurrachee to Kotree, and from Mooltan to Lahore.

It was not now possible to estimate that charge in a definite way, because it had not yet been determined what arrangements should be made at the junctions between the new narrow-gauge lines and the old broad-gauge lines. Taking the most unfavourable view of the case, it seemed impossible to suppose that a greater outlay than £500,000 could be necessary; which would still leave a total advantage on the Punjâb lines of about £1,000,000.

Those figures did not take into consideration the greater economy of maintenance on the narrow-gauge lines, which would probably be in proportion to their greater economy in first cost. It was difficult to estimate that element of saving at present with any useful amount of precision; nor did he think that account of it could properly be taken in this discussion, as it did not concern the capital outlay. Mr. Hawkshaw, however, had reckoned it to be equal to the whole saving on the first cost of the permanent way, and on this standard the additional amount to be credited to the narrow-gauge lines would be more than three-quarters of a million, thus raising the whole saving to about two millions.

But he readily admitted that he did not attach any particular weight to the exact amount thus arrived at. What he desired to affirm was that there seemed complete evidence of a very important saving, due to the adoption of the narrow gauge; and that the only countervailing disadvantage, the break of gauge, was not one which would, under the actual circumstances of the traffic, render the saving illusory or nugatory.

So far as the interests of commerce were concerned, he entirely agreed with the Author that a single break of gauge at Lahore between the lines down the Indus Valley and up to Peshawur, and those leading to Delhi and the eastward, might be altogether disregarded. Even the double break that would be caused by the interposition of the mètre gauge between Kotree and Mooltan, if no change whatever were made in the existing broad-gauge lines, he should regard commercially as of little importance. The cost of the transfer of goods would be very much more than compensated by the reduced interest on the capital saved. It was not in the least to the point that a break of gauge in England, under circumstances of a totally different nature, had been found to be intolerable. To complain of the injury done to the traffic on the

Indus Valley railway because vehicles started from Delhi, for instance, would not be able to pass to Kurrachee, would not be less visionary than a similar complaint as to interchange of traffic between Russia and Spain. No tendency to any such traffic could arise that would have the smallest practical importance.

As to the railway from Lahore to Peshawur, it was equally visionary to anticipate any export traffic except of the smallest amount. There was hardly any cart traffic in the districts west of the Ravee, and beyond the Jhelum that sort of conveyance was impossible, except along the line of road now to be occupied by the railway. As to the import trade from the west, the one item of any importance would be salt. Now the retail selling price of salt in the districts of the North-Western Provinces, where the more important consumption took place, varied from 3 rupees to 4 rupees per maund, or say from 160 shillings to 200 shillings per ton. If the cost of transfer at Lahore, from the narrow-gauge wagons that brought it from the mines to the broad-gauge wagons that carried it on to the markets for it in the east, amounted to 4*d.* per ton, the result would be an increase to the retail price of no more than from $\frac{1}{6}$ per cent. to $\frac{1}{8}$ per cent., a quantity quite inappreciable. If any one thought 4*d.* per ton too little for the cost of transfer, he could readily correct the calculation; but the most extravagant estimate would not raise the charge to 1 per cent. on the selling price.

He was somewhat at a loss to follow Mr. Hawkshaw's remarks as to the necessary evil of break of gauge apart from the extent and nature of the traffic; and such extreme doctrines as that gentleman appeared to advocate struck him as little less ludicrous than an assertion, that the original cost of loading goods into wagons rendered railway transport in all cases commercially impossible, because this might be true in some extreme case.

As to the effect of the break of gauge on possible military operations in the Punjâb, he agreed entirely with the Author. To argue on this point from any experience obtained from military operations in Europe, without a careful discrimination of the features which would be alike and different in any possible war on the Punjâb frontier, could lead to no conclusions of any value. He should not attempt to enlarge on the possibilities of war in India, or to imagine the circumstances under which troops or military stores might have to be moved by railway in that country. All that he need say was, that the narrow-gauge lines under construction would be as efficient in the transport of troops and stores, within the practical necessities of the case, as any broad-gauge

line that could be made, without going to an expense vastly in excess of anything that had ever been seriously suggested.

A single line of railway, having very severe gradients for a considerable part of its length, could not be regarded as an efficient instrument for moving large bodies of troops, accompanied by horses and guns, and the other impedimenta of an Indian army; and this was equally true of a 5 ft. 6 in.-gauge as of a mètre-gauge line. On the other hand, as far as the supply of stores was concerned, the narrowest-gauge line ever constructed would readily meet all the demands of any army that was ever likely to be put in the field on the Punjâb frontier.

It was not to be supposed that he denied the general advantage of continuity of gauge and the corresponding disadvantage of break of gauge—very far from it. If the 5 ft. 6 in. gauge could have been retained consistently with other necessities of the case, no one would ever have proposed a change. Now what were the facts? Having provided about 5,000 miles of railway, the country found itself burdened with an annual payment of one million and three-quarters in respect of those lines, in excess of all receipts, and with little prospect of any early or considerable relief from this heavy financial burden. Further, it was apparent that under the existing system of construction and management, it could hardly be expected that any more railways could be made without leading to a permanent charge on the revenues of from 2 per cent. to 3 per cent. on the whole capital outlay required. It was under these circumstances that the Government of India, seeing the great importance of the extension of railways, determined to seek some more economical system under which this extension might become possible. The conclusions come to were, that all lines should in the future be carried out without the intervention of companies, and that the outlay on construction should be reduced to a minimum, by the adoption of the narrowest gauge and the lightest rails and rolling-stock, compatible with the requirements of Indian traffic.

Now it was not to be supposed that so serious a change could be made without strong opposition. It would also be apparent how the two parts of the policy of the Government—the suppression of the companies and the change of gauge—were almost necessarily bound up together, particularly in the outset, and with respect to those districts where existing companies supposed they had claims to carry out suggested extensions. The success of the new policy of the Government depended on its being applied on a large and consistent plan; and any hesitation in applying it on

the first occasion on which it seemed likely to be productive of decided economy would very possibly have led to its total miscarriage. It could not be admitted that the economy likely to be obtained by the new policy of the Government would be limited to the saving of first cost on the new lines of railway, though this alone would fully have justified it. The economy due to the change of system of management must not be lost sight of as an essential part of the plan. Therefore, in order to estimate the whole financial advantage of the new policy in the Punjâb, a question of great complexity had to be dealt with, which, though it related to engineering operations, involved grave considerations of financial and political importance, and thus became one of general administrative policy.

The responsibility for coming to a decision on this question rested with the Government of Lord Mayo and the Duke of Argyll; and their decision was in favour of the system of construction which the Indian Government began to carry out about two years ago.

It might also be observed, that the course which the Government of India had thus felt itself compelled to adopt, was that which other poor countries had also lately adopted in many other parts of the world where, as in India, capital could only be obtained from foreigners and on an absolute guarantee of interest, and where the traffic prospects were poor. The recent development of narrow-gauge railways in the southern parts of the United States of America showed that the experience of that great commercial country was not in opposition to the adoption of cheap lines of railway, involving break of gauge, under certain conditions of traffic and first cost.

Although there were many other developments of the subject which might have served, in his own opinion, to strengthen his argument, he felt that he should not be justified in further intruding on the patience of the Meeting, except in relation to one or two matters from which the course of his argument had gradually led him away.

First, as to the proposals that had been made, that broad-gauge lines should be constructed with light rails, say from 42 lbs. per yard to 45 lbs. per yard, in preference to lines of a narrower gauge.

He had said, in relation to the Punjâb lines, that the alternative did not, in fact, arise; but the objection that existed in that case would not necessarily apply in others. If required to state shortly his own conclusions on that point, he should say that the narrower gauge necessarily possessed a certain amount of financial advantage; and that if 45 lbs. rails or 42 lbs. rails were suited for wagons carrying 16 tons on 4 wheels, such as those of the broad gauge,

a far lighter rail would suffice for wagons carrying, on the same number of wheels, only half that load; and that the assumption by the advocates of the light broad-gauge lines that the narrow-gauge lines must have 40 lbs. rails, was untenable, and their comparative estimates based on that assumption worthless.

Further, he concluded that the presumption, in such a country as India, would be in favour of a narrow-gauge line, if the length of it was such as to justify a break of gauge, having regard to the probable traffic; or if, from the nature of the case, there was an obligatory break of gauge, caused by a great river virtually impassable, or by some other physical obstacle. For short isolated branches for broad-gauge lines, a broad gauge would still be essential.

He considered that for Indian traffic there was a decided and substantial advantage in the use of the smaller vehicles of the narrower gauge, and that this advantage would be greater in proportion to the smallness of the traffic.

At any time the doubling of a narrow-gauge line would give an almost indefinite expansion to its carrying capacity—as referred to an Indian standard—at an additional cost that would be small; and long before the carrying power of a single line was exhausted, the interest on the capital outlay would be covered, and it would have become financially productive and able to pay for its improvement.

Next he would say a word as to the manner in which these proposals to adopt light broad-gauge lines had been brought forward. Until the Government of India announced its intention of carrying out narrow-gauge railways, as the only apparent means of obtaining cheap railways, none of the Engineers of the Indian lines —exclusive of the Oudh and Rohilkund Company and the Indian Tramway Company—suggested the construction of light or cheap lines, or admitted that they were possible. Long after the necessity for reducing the cost of Indian railways had been strongly asserted by the Government, the projects and estimates prepared by the engineers of the guaranteed lines continued to maintain their old character. Without going back to the history of the first-constructed broad-gauge lines (or even of those which, like the Delhi and Lahore line, served to bring the Government to adopt its present railway policy), it would be found that the latest project for the broad-gauge line along the Indus Valley, which had been superseded by the narrow gauge, was to have cost more than £11,000 per mile. The proposed lines in Rajpootana were set down at from £12,000 per mile to £14,000 per mile. A line pro-

jected between the two branches of the Great Indian Peninsula Railway was estimated at £12,500 per mile, and rejected by the Government as financially impossible, without any proposal on the part of the engineers that it could be constructed for a smaller sum; and this list could be extended. He stated without hesitation that in all those cases the corresponding cost of a suitable narrow-gauge line would not exceed £7,000 per mile, and might be less.

He made no complaint on that score; but he drew attention to the fact, that it was now asserted that those lines might be made on the broad gauge virtually as cheaply as on the narrow gauge, and that this remarkable change of opinion was coincident with the announcement of the change of the policy of the Government.

So that the Indian Government might congratulate itself on the happy conclusion that, whatever might be the waste which, according to its opponents, would accompany the adoption of the narrow gauge, its adoption had, at all events, had the effect of opening the eyes of the broad-gauge engineers to possibilities of economy in the construction of such lines, of which they before had no conception.

Mr. G. B. Bruce said they were much indebted to General Strachey for having stated so fully, so clearly, and so fearlessly his own views upon this important matter; and knowing, as they all did, the part which General Strachey had taken in India in connection with this case, it was extremely important they should have from him a clear and explicit statement of his own views, and the grounds for the conclusions at which he had arrived.

With regard to the first statement in his communication, in which General Strachey said this Institution seemed to think the Government ought to be guided by the opinions of the Civil Engineers, he had assumed, in the first place, that the gauntlet was thrown down by the Institution or by those who, like Mr. Bruce, held it was a mistaken policy to introduce a break of gauge. This was not the case. The discussion was introduced here fairly and fully by a conspicuous member of the Indian service—holding a high place at the India Office—bringing a Paper before the Institution; therefore, when that Paper came to be discussed, the Government must not be surprised, and he thought this Institution was not liable to blame, when it was found the discussion turned almost entirely upon purely technical questions. There were good reasons why it should do so. The Author had based his arguments entirely upon technical grounds. He told them that "the one solitary reason of the Indian Government for adopting a narrow gauge was belief in its superior economy." He did not say

one word about policy, or about the blindness of men who had not been in India to understand Indian affairs, but he confined himself simply to the question of cost. To that point Mr. Harrison, Mr. Hawkshaw, and Mr. Bidder had applied themselves, fairly and properly, because it was strictly within, and did not go beyond, the limits of the Paper.

They were told that the smallness of the traffic was a good reason why there should be a narrow gauge. He thought General Strachey was about twenty-five years too late in telling them that. The question now was, not to fix a gauge for the first time, but whether, having made 5,000 miles of railways on a certain gauge they were to introduce a new gauge, and whether the saving thus effected would compensate for the evils which were admitted to be inherent in a break of gauge. Therefore smallness of traffic was not the question, unless it could be shown that the difference of price was very considerable. It was stated that the question which had to be decided was, not whether there was to be a light broad gauge, but a light narrow gauge or a heavy broad gauge. Now, Mr. Bruce thought if the Government authorities, finding themselves in difficulty as to how these railways would be constructed cheaply, had allowed others to suggest how it could be done, he was satisfied some mode of doing so would have been fully laid before them; and as to anything that could be said against making the wider gauge with light rails, and working it with light rolling-stock, Mr. Harrison had told the meeting that the standard gauge in this country was for years laid with light rails, and was for years worked with light rolling-stock. Thirty years ago some engines were put upon the Grand Junction Railway which were objected to on the ground that they weighed a little more than 16 tons, which was less than the weight of the proposed Indian narrow-gauge locomotives. The engines he alluded to had for a time worked the great traffic of this country, and it would be easy to use the same kind of engines on the ordinary standard gauge of India. General Strachey however assumed, that with the wide gauge they must necessarily have heavy engines, and therefore they were obliged to have heavier rails on the broad gauge than on the light; and then he suggested the question, Why did not you gentlemen suggest that these rails should be laid so in the first instance? Mr. Bruce had some experience of Indian railway economy, and, generally speaking, it had not been, at least so far as regarded the Govermental bodies, satisfactory; in fact, there was a decided dislike in all large bodies like a Government to allow anything to be done out of the ordinary way; and if the sug-

gestion to lay down a portion of a line with 40 lbs. rails, as now proposed, had originally been made, the reply probably would have been, "We don't see the use of it; do as you have been doing hitherto."

General Strachey had stated that the narrow-gauge line could be made for £7,000 per mile. Mr. Bruce thought some Members of the Institution had constructed railways on the 5 ft. 6 in. gauge for that amount per mile, or even less; therefore there was nothing new in the proposition. It had been done already by gentlemen then present; in fact, he had done it himself on a line not far distant from the sea; although the question of transport of the rails was not a serious item. He did not recollect the price of the rails, but that would affect both cases in the same way.

He had carefully followed the remarks made by General Strachey, and he would especially guard himself against appearing to be the opponent of any gauge. He believed in all gauges, and he thought every wise man did the same; and where it was found, as in the cases alluded to, in many of the colonies and in other places, that the narrow gauge had been selected, and it had been carried out largely, he would as much oppose the introduction of a wider gauge to interfere with the uniformity of the narrow gauge as he would in India oppose the introduction of the narrow gauge to interfere with the broad gauge. The principle he held was this: That in a country which had decided upon a particular gauge, and which gauge was to a considerable extent carried out, it was extremely unwise to alter it, because the difference in cost was so trifling as compared with the disadvantages of a break of gauge. In some cases it might be a question of railway or no railway; and no doubt there were instances where a small saving might present that alternative. That was not the case in India, and there was no difficulty in finding money for the construction of railways there.

It was stated that *4d.* per ton represented the money value of a break of gauge. He would like to ask Mr. Grierson whether *4d.* per ton, or anything like it, or even whether any money value could represent the disturbance of traffic? if it had done so, the Great Western would have continued to allow the large traffic to go past them, as they had done for a quarter of a century, to be carried by their neighbours? It was not merely money value; it was the disturbance of traffic, which they could not estimate at *4d.* per ton, or any other sum.

Apart from local questions, with regard to the Punjâb, the Author appeared to have based his statement of an alleged saving of

£1,000 per mile by taking the estimates of Mr. Hawkshaw and Mr. Fowler, and adding to them items which one or other of those gentlemen repudiated. He had not before him Mr. Hawkshaw's estimate, but, with regard to Mr. Fowler's estimate, there were one or two points to which he would draw attention. First, Mr. Fowler's estimate was a comparison between a 5 ft. 6 in. gauge and a 3 ft. 6 in. gauge. He gave a width of embankment for the wide gauge of 14 ft., and for the narrow gauge of 10 ft. 6 in.; that was, he made the embankment 3 ft. 6 in. wider for a difference of 2 ft. in the gauge. He should like to know what was the object of that? There was no sense in it. Then, as to sleepers, Mr. Fowler gave a sleeper of 8 ft. 6 in. for the wide gauge, and of 6 ft. 3 in. for the narrow; again, a difference of 2 ft. 3 in. for an increased gauge of 2 ft. He thought there was no sense in that. Then, again, with regard to ballast, Mr. Fowler told them they must have a depth of 9 in. of ballast under the sleepers of the wide gauge, and of 6 in. under the sleepers of the narrow gauge. Mr. Bruce maintained it should be exactly the other way—that it was more necessary to have the road good on the narrow than on the broad gauge. He would instance in the one case a broad-gauge carriage, and in the other a narrow-gauge carriage, each having one of the rails under it depressed to the extent of 2 in. The deflection of a rail to that extent on a narrow gauge would throw the carriage over into a position of danger, whereas such a deflection on the broad gauge would simply make it a little oscillating in its motion. That being the case, it was the more necessary to have the road well ballasted and supported on a narrow gauge than on a wide gauge; therefore, if any difference was made in respect of the depth of ballast, it should be exactly the reverse of what had been now proposed.

It so happened that just now 216 miles of mètre gauge were being constructed in the south of India. He had obtained the estimates of the line, and had examined them, to see what would be the increased cost of making it on the broad-gauge system. This was not a mere supposition, but a fact. The earthwork would come to £33 per mile additional; the ballast to £27 10*s.*; sleepers, £99; that was including freight to India, and carriage. The sleepers would cost 9*d.* each more; the iron girders would cost £10 per mile more. The girders for the larger spans were designed to carry the road on the tops of cross girders, and were 5 ft. 6 in. apart. There would be nothing to do but to move the longitudinal bearers out, so as to be immediately above the girders, and to widen the platforms, and the extra masonry for that would cause an increase of £10 10*s.*

per mile. Mr. Bruce put land at the same price as the Author, namely, at £10 per mile, though Mr. Harrison showed it was more like 10*s*. per mile. That made a total difference of £190—say £200—per mile, or, on 216 miles, of £43,200, as the total absolute saving of cost upon that line; and, supposing the line just paid its working expenses, the 5 per cent. guarantee would be £2,160 a-year; or, taking the normal condition of the railways as a whole—that they earned 3 per cent., and the Government had to make good the other 2 per cent.—it would cost the Government, or rather the unfortunate ryots, of whom so much had been said, £864 per annum to avoid break of gauge in that district of India. Applying this fact to the 10,000 miles assumed by the Author, how did it work? It would be a saving of two millions, and, taking 2 per cent. there again, that represented a saving to the Treasury of India of only £40,000 per annum, against which they had to put all the disadvantages of the break of gauge, which it was impossible to calculate; and he was certain, on facts like these, there could be but one decision in this Institution. He had left out of that calculation the additions of agencies and engineering, which, he thought, was shown by Mr. Harrison, did not require to be considered at all, because it would virtually be the same. He had likewise left out the £200 per mile added for curves, because they knew that, in ninety-nine cases out of one hundred in India, in the matter of such curves as they required, they would not save anything at all. He had also omitted the £10 per mile for maintenance, mentioned in Mr. Hawkshaw's report, for two reasons; in the first place, it was not first cost, and, in the second place, if they went into maintenance they must take the other side of the ledger, namely, what it took to maintain rolling-stock of that description; a much wider stock, and altogether a less mechanical stock, than the railway companies were in the habit of using, the increased maintenance of which might very soon occasion a loss of much more than £10 per mile.

The Author based his Paper entirely on the difference in width of gauge; he had left out of consideration the width of carriages. Mr. Bruce maintained that width of vehicles was a truer test of cost of line than the width of gauge. When an ordinary mètre-gauge carriage, constructed according to the Government regulation, was contrasted with wagons on the 5 ft. 6 in. gauge and on the 4 ft. 8½ in. gauge, it would be observed that, in the latter two cases, the journals came directly under the top bars, leaving proportionately little overhang in the wagons. Nobody could persuade him that by the mere moving in of those wheels, in the

case of the mètre gauge, while the wagons themselves were kept wide, the railway could be made any cheaper. The ordinary gauge of a carriage like that for the mètre gauge would be about 4 ft. 2 in. to render it an equally mechanical construction as those on the wider gauges.

A great deal had been said about economy in working, which, he supposed, was based upon the old idea of the difference in weight of stock. He had given attention to that point, and he made out, that if the gauge was widened from 3 ft. 6 in. to 5 ft. 6 in., supposing the wheels to remain the same, as they were not an element of the gauge, the weight of the wagon would be increased about 4 cwts.; and supposing the weight to have been 50 cwts. originally, the weight would be increased by 8 per cent., and the capacity by 24 per cent.; and the increase in width of the carriages would add 11 per cent. to the weight, whilst the capacity would be increased 24 per cent.: so that, so far as the element of gauge was concerned, there was nothing to be said, on that question, in favour of the narrower gauge. It might be true that the wagons and carriages were built a little too heavy, but that was not an element inherent in or dependent on the gauge. The only allusion to the working of the line was made by General Strachey. Mr. Bruce's own impression was, that a most fallacious and absurd stress had been laid upon the cheapness with which a narrow gauge could be worked; but he was prepared to waive that point, and not to take it into consideration in either case. A great deal had been said about the lines not paying; and they were told by the Author that it was only a reasonable supposition that the rates and fares of guaranteed railways were fixed with a view to the production of the largest revenue. He did not think Mr. Grierson would concur that he was free to develop the traffic of the Great Western Railway, to the fullest advantage for the shareholders, if the Board of Trade, in addition to their present powers, had the fixing also of the number of trains per day, the time of leaving and the time of arrival, as well as the rates and fares both of passengers and goods. No doubt these were fixed by the Government as much as possible for the interests of the State, not of the shareholders; but he knew, without going into the matter at length, many Indian railway managers demurred to the idea that the traffic was worked to the best possible advantage; therefore there was good reason for supposing that the railways had not reached their maximum, or that they had got all the trade they would have, if the lines were worked on commercial principles. There was no ground, therefore, in the present smallness of traffic

for reverting to a narrow gauge. The Author stated that it was all very well to send their broad-gauge wagons on to these light broad-gauge lines, and that in the event of war they would get a good supply of wagons, but they would not get engines. They knew very well they could not run broad-gauge engines over 40-lbs. rails at high speed, but in an emergency they could run those engines slowly, yet effectively; and those who understood how contractors ran heavy engines over light rails would see that on an emergency it could be done in India, and the whole broad-gauge stock of the country could be made available at any point, in case of war. It might be said—and was partly said by General Strachey—that if these lines could be made so cheaply as was stated, it was a pity it had not been already done. Mr. Bruce thought the reason why these lines were to be made cheaply, whereas the others had been made comparatively expensively, was because there was a different code of rules drawn up in the one case and in the other. He might mention, in the case of the Madras railway, he wanted to build his stations with low platforms. The Government thought it desirable to have high platforms. He argued, what was good enough for England was good enough for India; but they would have high platforms: consequently the expense of the stations was increased in every way. That showed the tendency had been to make everything on a colossal scale, whereas the governmental ideas now tended in quite the opposite direction. The true medium was perhaps just half-way.

He would venture to repeat that he thought the Government of India having made 5,000 miles of railway, and having the means of making as much more on the same gauge as they liked, almost as cheaply as on the narrow gauge, it would be the worst possible policy to construct those lines on the narrow gauge. He was perfectly certain—and he was confirmed in what he had said—that the difference of amount was less than £200 per mile. He was confirmed in this opinion by a letter from a Chief Engineer in the south of India, in which he stated his belief that £200 per mile was the whole amount of saving that would be effected by the change.

Mr. Carl Pihl said he was not prepared to make any remarks upon the Paper in reference to the general issues which had been raised as regarded the railways of India, as he considered there were not only technical, but also military and political considerations involved, with which, as a stranger, he felt himself incompetent to deal. But having had ten years' experience in the construction and working of the narrow gauge in Norway, he could state that

all parties felt it answered the purpose there, and the narrow-gauge lines had been built considerably cheaper than those on the broad gauge[1]. It was owing, no doubt, to the cheapness of construction that Norway was indebted for even such railways as she had. The traffic had not yet reached the present capabilities of the railways, so that he did not see why, under similar circumstances, a cheap system of construction should not be adopted. There was also a line of railway of 4 ft. 8½ in. gauge about 100 miles long in Norway, and they were about to make another 100 miles. The length of the narrow-gauge lines was about 200 miles, and another little line of 40 miles was to be made. With reference to the difficulties and disadvantages of a break of gauge, of course he could draw no comparison between the circumstances of such a line as the Great Western and those which existed in Norway, where they had no such circumstance as the narrow gauge competing in the same districts with the broad gauge; and in such a state of things no one could question the wisdom of abolishing the exceptional gauge, and substituting the uniform gauge of the country; and that being done, the most important question was the disposition of the rolling-stock of the broad gauge; but the adaptation of it to the narrow gauge was a much easier task than that of expanding narrow gauge stock for adaptation to the broad gauge.

There were at present in Norway about 100 miles of broad gauge, and 100 more expected to be constructed; whereas of the narrow gauge there were about 200 miles in operation, 200 miles under construction, and about as many more in contemplation. In Norway a break of gauge between a narrow gauge of about 300 miles and a broad gauge of 42 miles in length would have to be encountered, but in that case it was justified, as the inconvenience of a break of gauge by no means balanced the economical advantages which arose from the adoption of a cheap line for so great a length. Though fully impressed with the inconveniences of a break of gauge, he considered that question to be one that in all cases had to be weighed in connection with the gains expected from the change. He could therefore not see the justice in bringing forth the experience from the Great Western as a warning instance in every case, for there was no comparison between the circumstances of such a line and those in Norway, or other countries similarly situated. Under such a state of things as existed on the Great Western Railway of England, no one could question the

[1] *Vide* also ante, p. 36, foot note.

wisdom of abolishing the exceptional gauge and substituting the uniform gauge of the country. In this case it should not be lost sight of, that in that instance it was an already existing broad road that had to be changed for a narrower one. That in itself was a matter of no very great expense. It was the dealing with the rolling-stock that was the real difficulty, but in that the directors of the Great Western railway had no doubt for a long time been prepared, and the change was no doubt facilitated, and its expense lessened, by its being carried gradually into operation in successive portions of the Great Western railway system.

Mr. C. D. Fox said the Institution was indebted to the Author for bringing forward, in this open arena of discussion, a question which had hitherto been too much confined to pamphlets, and in which, as it appeared to him, two very different subjects, namely, that of gauge and that of light or heavy construction, had become mixed up. Comparisons had been made between the cost, both of construction and of working, of different railways, from the Great Western railway of 7 ft. 1 in. gauge, to the Festiniog line of 1 ft. 11 in. gauge; and, on reading some of the arguments put forth and purporting to be based upon such comparisons, one gathered that the difference of cost depended entirely upon the gauge. The absurdity of such a notion need not be commented upon.

With reference to the general question of the gauge of railways, it was evidently impossible to lay down an empirical rule. He would venture to suggest that, if an engineer was to do his duty properly, he must have no foregone conclusions on this or on any other question, his duty being to investigate the circumstances of each case, and to apply his experience to those circumstances in the best possible manner. Thus, if it was a question of high speed and heavy traffic, he thought it would be agreed that the English standard gauge of 4 ft. 8½ in. was in every way suitable. It appeared to him a fact much to be regretted that in India, in Canada, and in several of the colonies, and also in Ireland, a wide gauge should have been adopted. The agitation for a narrower gauge would probably hardly have arisen in connection with India, had the standard gauge been the same as in England. But whilst the English gauge was well adapted for its purpose, there were countries and districts in which it was very important to keep down the cost, and, in doing so, where circumstances had not rendered such a step undesirable, he had found it advantageous

to adopt a narrower gauge. For instance, in the colony of Queensland the 3 ft. 6 in. gauge was adopted for the Government railways, 220 miles in length, with which he was connected, and it had proved a great success, but in that instance the question of break of gauge was not involved. In Canada likewise, the same gaug had been adopted, under his advice, for 250 miles of railway running from Toronto. In that instance break of gauge had to be considered, but the circumstances were of a special nature. On the one hand the standard gauge was 5 ft. 6 in., and on the other, it was of the greatest importance that the new line should be made with great economy; and when he spoke of economy, he was not dealing with such an amount as arose in the case of the Indian railways, but with a question of a few hundred pounds per mile. It was found that £3,000 per mile could be raised from the resources of the country; but that, if the cost came to £3,500 per mile, it would be impossible at that time to construct the railway. It was therefore necessary that everything should be done to keep down the cost to the smaller amount. The population of the country was very thin, and there was no military question involved—for, instead of running up to a frontier which was threatened, as the northern frontier of India was, by a neighbouring state of great military power, these lines ran from a populated centre on the great chain of lakes up to the backwoods, the object being to open up the country, and to carry population where it did not exist, and in that way to add to the commercial resources of the district. With regard to the Government railways of Norway, also on the 3 ft. 6 in. gauge, he had already laid before the Institution[1] a description of their salient points, and, in justice to Mr. Carl Pihl, the Engineer for the Norwegian Government on that line, it must be stated that it was he who, long before the question of a narrow gauge had been brought prominently forward, had worked out in very complete detail a system of railways economical yet efficient, and thoroughly adapted to the requirements of that country.

He considered that these and other railways of the 3 ft. 6 in. gauge had demonstrated very completely the efficiency of that gauge, when it was adopted under suitable circumstances; but it would, nevertheless, in his opinion be most injudicious to introduce either that, or any other gauge differing from that of the main lines, in cases where the standard gauge was of moderate width, where the branches to be constructed were comparatively short, where

[1] *Vide* Minutes of Proceedings Inst. C.E., vol. xxvi., page 49.

the traffic was likely to be considerable, or where through communications were important for military purposes.

This led him to make a few remarks upon the subject of a break of gauge, upon which a great deal had been said, based upon the experience of the Great Western Railway Company. He quite agreed with the remark of Mr. Pihl, that the prejudicial effects of a break in the gauge of a system of railways must be measured by the special circumstances of each case. These effects must be serious where lines were short, where time was valuable, and where, as in England under the admirable arrangements of the clearing house, rapid interchange of rolling-stock was possible, and still more serious, when, as in the case of the Great Western, a railway suffering from a break of gauge was exposed to severe competition for through traffic from powerful rival lines having but one gauge throughout, or when, as in India, the military question had to be considered.

Such a break of gauge, however, became less important when it only occurred once in a large system; and in cases where time was comparatively of small value, where no military question arose, and where exchange of rolling-stock was from the great length of the lines practically impossible, or of very rare occurrence. And on this last point he would venture to state what had been the experience of some of those who had had to do with the interchange of rolling-stock in America. It so happened that, until lately, three lines, belonging to different companies, but of the same 5 ft. 6 in. gauge, met at Toronto, in Canada, and yet the inconveniences attending the exchange of stock were so great, that there were very few instances of the cars of one company being sent over the lines of the other companies. If a wagon were thus sent, it was probably not seen again for weeks. The General Superintendent of the Erie railway, a large and important system, wrote thus:—"I confidently believe that the experience of railroad managers generally will bear me out in the remark, that a road 500 miles in length, with a gauge that does not correspond with that of any independent line with which it connects, enjoys in this particular an enviable position."

Even in this country the return of empty wagons had become a serious matter, so much so indeed, that the North Eastern and other companies in England were discouraging as much as possible the use of private wagons on their lines. It would be interesting to know to what extent wagons were run through without breaking bulk on the 5,000 miles of uniform gauge now existing in India.

Mention had been made of the alteration of the gauge on a considerable portion of the Great Western system in England. A similar process had been in action on the Great Western railroad in Canada, and on a portion of the Grand Trunk lines, where the gauge had been altered from 5 ft. 6 in. to 4 ft. 8½ in., and on the Ohio and the Mississippi railroad, which had been reduced from 6 ft. to 4 ft. 9 in. It was worthy of notice that in each case the change had been from a broad to a narrower gauge. In the United States, where there were more than 50,000 miles of railway of the 4 ft. 8½ in. or of wider gauge, lines of the 3 ft. gauge were now being largely introduced in localities where great economy was necessary. He, however, believed that it would have proved more satisfactory had the gauge for these lines been fixed at 3 ft. 6 in.

The capacity of the 3 ft. 6 in. gauge was a question upon which he desired to say a few words, as it appeared to him there was some misconception upon the point. He had read a very elaborate argument against the narrow gauge, based upon a maximum width of wagon of 4 ft. 9 in. He also understood that the designs for the Indian State railways were based upon a maximum width of only 6 ft. 6 in. This latter was the width adopted for the Queensland railway, but the experience there gained had enabled him to go as far as 8 ft. 6 in. in width on the 3 ft. 6 in. gauge in Canada, and on these railways the traffic was carried by rolling-stock of which the following were examples: —Passenger cars upon the American system, 31 ft. long, 8 ft. 6 in. wide, and carrying 38 passengers. Freight cars, some 15 ft. long by 8 ft. wide, carrying 12,000 lbs., others 30 ft. long by 7 ft. 6 in. wide, carrying 20,000 lbs. Locomotives on 6 wheels, coupled, and a leading bogie, cylinders 14 in. by 20 in., weighing 26 tons, exclusive of the tender, and hauling 250 tons upon gradients of 1 in 60 at speeds of 15 miles per hour; tenders carrying a cord of wood and 1,000 gallons of water. This stock had been found to work steadily, smoothly even at high rates of speed, and round curves of 5 chains radius. The traffic in Canada consisted largely of logs and sawn timber, flour in barrels, grain, and cattle; and in Queensland, of wool and cotton, articles similar to those which would be carried in India.

On the 5 ft. 6 in. gauge, it was found practically unnecessary to adopt any stock wider than 8 ft. 5 in., although, so far as safety was concerned, the width might have been increased to 11 ft. Thus it happened that, dealing with things, not as they might be theoretically, but as they were, the narrow-gauge stock of

Canada was almost identical with the broad-gauge stock of India, as regarded the height from the rail to the top of the roof, and absolutely so as regarded width, the centre of gravity being, however, lower in the former than in the latter case.

It appeared to be of great importance, in view of the character of the traffic in India, that the stock should not have a less width than 8 ft.; but he thought that a width of 8 ft. 6 in. would be preferable.

He considered it very undesirable, except under special and exceptional circumstances, to adopt a gauge of less width than 3 ft. 6 in. Upon this gauge, experience had proved that locomotives could be constructed with fire-boxes large enough to produce good results; but every inch of diminished width in an engine, having, as usual, the fire-box limited by the distance between the wheels, would tend to seriously cripple its power.

With reference to the cost of working, having had considerable experience of the 3 ft. 6 in. gauge, he could state distinctly—as, indeed, common-sense would lead any person to expect—that there was no appreciable difference between the cost of running a train or of hauling a ton of goods on the 3 ft. 6 in., on the 4 ft. 8½ in., or on the 5 ft. 6 in. gauge. Supposed examples to the contrary, which had been largely made use of in arguments in favour of extremely narrow gauges, might readily be shown to be entirely illusory, and it was much to be regretted that the subject should have been surrounded with statements which could not be borne out in practice. There was, of course, a considerable saving in maintenance on a light narrow-gauge, as compared with a heavy broad-gauge railway; but if the rolling loads and the weight of rail were made, as they might be, the same on both gauges, the difference would become hardly appreciable.

As regarded the comparative cost of the broad gauge and of the narrow gauge, he would remark, that this would vary greatly according to circumstances, but he believed that the practical difference would be greater than the theoretical difference, as the saving had been found, in fact, to pervade every department. In Canada, the cost of the 3 ft. 6 in.-gauge lines, complete in every respect with the exception of rolling-stock, had been £2,800 per mile, the rails weighing 40 lbs. to the yard; whilst a railway of 4 ft. 8½-in. gauge, with rails weighing 50 lbs. to the yard, and running through the same district, had cost, in like manner, exclusive of rolling-stock, over £4,000 per mile. In Queensland, owing to the heavy nature of the works on the Main and Liverpool ranges, there could be no doubt that the adoption of the narrow gauge, and the system

of construction accompanying it, had resulted in a very large saving. In India, however—where the larger proportion of the country had very little inclination, and much of it was perfectly flat; where the chief works consisted of bridges of great length, the piers of which must in any case be strong enough to resist floods, and the girders of which would be much more affected by rolling load than by gauge; where the embankments must be wide to resist the heavy rains, and where ample ballasting was, in either case, essential,—the difference of cost of a light line on the broad or the narrow gauge was certainly reduced to a minimum.

The principle of introducing a lighter mode of construction on the standard gauge having been determined by legislation in England in 1868, the Carnatic Railway Company entered into a contract with the Secretary of State for India, early in 1870, for the construction of their line upon the standard gauge, with rails weighing 45 lbs. to the yard, and having works so designed as to take all the rolling-stock of the existing lines, excepting the locomotives. Some progress was made, and locomotives were prepared from Mr. Fox's designs, for the 5 ft. 6 in. gauge, having no greater weight on a wheel than 4 tons, such being the maximum weight on any of the existing wagon or carriage-wheels. Since, however, the question of the adoption of the mètre gauge had arisen, further progress in this direction had been suspended, and fresh surveys and estimates were asked for by the Government, based upon the mètre gauge. There could be no doubt that a considerable saving, both in first cost and in maintenance, could be effected, without any alteration of gauge, by reducing the weights upon the driving wheels of the engines to the same as those of the other stock; and, especially in India, where high speeds were not generally required, and sharp curves were rarely necessary; and that this could be attained, without materially reducing the power of the locomotives, or introducing any abnormal types of construction. This being done, the weight of permanent way, and of the superstructure of bridges, could be reduced almost as much as if the narrow gauge were adopted. The reduction might be quite as great, were it not that, in designing stock for a light broad-gauge railway, it must be made suitable for running intermixed with existing stock, and of withstanding the heavy shocks of shunting and the higher speeds of the main lines, and also that the permanent way and bridges must be strong enough to bear the existing stock. Were a narrow gauge adopted, central buffers could be introduced, the weight of the under-frames be reduced, the centre of gravity lowered, and the rolling load be brought down to about 3 tons per wheel, with a proportionate diminution of weight and

cost throughout. If, in order to avoid a break of gauge, light broad gauge lines were introduced, some precaution, either mechanical or legislative, would be essential to prevent their being used by the heavy locomotives of the existing lines, and to regulate the speed of the trains. In England he had found it practically impossible to make use of the light system, as the main line companies insisted, where they were to work the branch, that it should be so constructed as to take not only their rolling-stock, but their heavy locomotives; but in India, the Government, having the control, could avoid a difficulty of that kind.

Having thus briefly remarked upon the general principles arising out of the discussion, he would desire to say a few words upon their special application to the case of India. One could hardly look at the map before them, especially the upper part of it, having in view the fact that the proposed lines in North-Western India derived their chief importance, not from commercial, but from political and strategic considerations, without feeling that—even if the saving of first cost, claimed by the Author, should result from adopting the narrow gauge between Kotree and Mooltan, and between Lahore and Peshawur, narrowing the Scinde railway to the mètre gauge, and introducing the mixed gauge between Mooltan and Lahore,—all which he ventured to doubt,—the break of gauge at Lahore must prove most serious, not to say suicidal, in a military point of view. The Government, through the Companies, had provided itself with 5,000 miles of railway on the 5 ft. 6 in. gauge, bringing the more important military centres into direct and unbroken communication with Lahore. It was now necessary, in order to protect the frontier, that the system should extend to the port of Kurrachee on the one hand, and to Dadur and Peshawur on the other; and it did appear to him that, unless this were effected on the broad gauge, so that the existing rolling-stock—and even the locomotives at low speeds—might pass freely to the frontier, the chief value of these extensions would be lost. He could not but regard with disfavour the proposal to introduce the mixed gauge on a system of this kind; for, having had some experience of it in connection with one of the metropolitan termini, and elsewhere, he could bear testimony to the complications and inconveniences which accompanied its use, and which would, in his opinion, render it in the present case an evil only second to that of a break of gauge. As regarded the Punjâb, then, the case seemed to him to be most clearly in favour of the broad gauge, unless—which he had not heard suggested—the Government contemplated the reduction of the existing system of railways to a narrow gauge.

If there were any such intention, he would certainly hesitate to select as the standard so narrow a gauge as that of the French mètre, or to permit, for the purposes of the Indian traffic, the reduction of the width of rolling-stock below 8 ft.

As regarded many other parts of India, the question appeared to be different; and in Mysore—and on the proposed line to Carwar especially—it might perhaps be found that sufficient economy would result from the adoption of a narrow gauge to justify a break of gauge. In the case of the Carnatic railway, the estimate showed—even through the level country of that district—a saving of fully 20 per cent. by the introduction of the mètre gauge, and a very light construction, as compared with such a broad-gauge line—lighter than the present main lines which the Government were then prepared to sanction—and such a saving was important, at any rate in the interest of a railway company, if not in a national point of view. He however believed that, if the Government permitted all the economy which was practicable, still retaining the standard gauge, the difference of cost might, owing to the character of the country, and the large number of bridges which would not be affected by the gauge, be reduced to some such insignificant amount as that referred to by Mr. Bruce; and he certainly felt that any such saving ought not to be allowed to influence the decision of so weighty a question as that under discussion, fraught as it was with momentous consequences as regarded the future welfare of the Indian Empire.

Sir G. B. Airy, P.R.S., Astronomer-Royal, remarked that, after the able critical examination which had been made of almost every engineering point, with regard to the proposed system of railways in India, it was not in his power to throw any additional light upon that branch of the subject; but there was an important, and, perhaps, the most important part of the question, on which he might speak. He was a member of the Royal Commission appointed in 1845, to consider the question of the break of gauge, and which made its final report in 1846. The question of the break of gauge was then beginning; in fact, there was only one place where the two gauges at that time actually met, and that was at Gloucester. The Commission did their best to examine into the whole state of things at the one break of gauge, and as to the probable state of things that might ensue. They studied the working of the traffic at the Gloucester station; they obtained the best evidence; they examined Mr. Brunel's ingenious contrivances; and the conclusions at which they arrived, and of which they felt the correctness very strongly, were these:—In

the first place, that there must be no such thing as a break of gauge,—that it was absolutely necessary that one gauge should run all through the kingdom;—and they thought it desirable that this should be the narrow, or 4 ft. 8½ in., gauge. But there had been much discussion on what could be done on railways of different breadth, upon which they had not sufficient evidence at the time. The Commission recommended that attention should be given to the possibility of the admixture of gauges; but that at all events the first principle should be carried out; and in a subsequent letter addressed to Sir E. Ryan, the Astronomer-Royal individually urged the same thing more strongly, and especially that attention should be given to the possibility of working a mixture of gauges; for the Commission held it to be important that liberty should be given as far as possible, and that Mr. Brunel's contrivances, admirable in many respects, should not be driven out of the field without receiving further trial. The Report of the Commission was strongly attacked, in pamphlets and in newspapers, by the advocates of the broad gauge, and finally it was resisted so strongly in the House of Commons that it was thrown out. He had watched the progress of events since that time with some interest, and he found it was this; that the Great Western railway, which naturally was the most strenuous opponent of the Report in the first instance, at length adopted precisely what the Commission recommended with regard to the gauge; trying first, the mixed gauge, and afterwards abandoning the broad gauge entirely, substituting for it the narrow, or 4 ft. 8½ in., gauge, which was now universal throughout the kingdom. And he could not help recollecting that amongst the representatives of the broad-gauge system there was one who especially commanded the respect of the Commission; that was the present Chairman of the Great Western Company, who was then the locomotive-superintendent, and was very strenuous indeed in his support of the broad gauge; but, nevertheless, the Commission felt it necessary to express an opinion opposite to that which that gentleman held; and even he had been driven by the force of circumstances to take the course which was recommended in the report. After this the Astronomer-Royal need not say his own feeling against the break of gauge in India, or anywhere else, was very strong indeed; and looking, not so much at the recommendations which the Commission made, as upon the course which events had forced upon railway companies, it did seem to him an act of most extraordinary imprudence to introduce a break of gauge in India.

There was one point which he omitted with respect to the break

of gauge, and it was this:—Numerical estimates had been given of the inconveniences of the break of gauge, and it was stated that goods might be transferred at from 8*d.* to 1*s.* per ton. Now he apprehended such a statement as that could only apply to goods on a large scale, such as bags of cotton, or rice, or barrels of flour, or articles of that character; but it could not apply, he thought, in any degree to mixed merchandize; and still less would it give the slightest idea of the injurious effects if a break of gauge occurred in the transport of an army, or of its munitions. As to having a stock of carriages of one gauge ready to meet a stock of carriages of another gauge, he looked upon such a proposition as an absurdity, and it had been so regarded, in an instance which preceded the Commission on the gauge question, on the Eastern Counties railway. The circumstances were these:—A short railway, which was likely to have communication with the interior of the country, and was 4 ft. 8½ in. gauge, was amalgamated with a longer railway upon a wider gauge. Upon that amalgamation taking place, the Directors of the amalgamated company immediately saw they could not go on under the existing state of things, and they at once changed the gauge of the rails and the working stock of the longer railway to suit those of the shorter line; and upon that no doubt depended the efficient existence of those railways. That was an instance, he would state, showing the impossibility to provide what was necessary upon one railway by the stock meeting it upon another railway. But with regard to the break of gauge in India, he would say he conceived it was impossible to provide a rolling-stock upon one railway which should be always ready to meet that upon another gauge; and from the evidence before the Gauge Commission, as well as from ordinary observation, there could be no doubt that the difficulty of a break of gauge in military matters would be extreme. India had not been held in subjection by the governing classes of Great Britain in the same way as England or Scotland; by the sword it had been gained, and by the sword it must be held. And however much legislation on behalf of that country might recognise the desirability of studying the welfare of the natives of that country, it must be remembered that there was a spirit of independence generally at work, and there were parties ready at all times to stir up internal tumults; while at the same time there were those outside who, at the proper time, would be ready to invade. It was necessary, therefore, to be prepared to make rapid movements of armies. With the means of rapid communication to the frontier of

Peshawur, at the opening of the Khyber Pass, it would be a question whether it was necessary to maintain so large a garrison there; and the advantage of landing troops without the fatigue of marches—especially in India—was too well known to admit of any question.

Adverting now to the question of the width of gauge as applied to India, he conceived there was not that objection to the wider gauge which some eminent men appeared to entertain; but as between the entire adoption of that gauge and of the change of gauge the difference was very great indeed. Amongst the objections which might be raised against the narrow gauge, he conceived there was one of considerable importance with regard to military matters. It would be difficult, he thought, upon the narrow gauge to carry field artillery except in a dismounted state, and it would be very troublesome to carry horses; and it was to be considered that the carriage of a large number of horses was indispensable in military matters. Even with infantry regiments the officers must be well provided with horses; and to carry horses at any speed on the narrow gauges which were proposed, he thought would be a very hazardous matter. With regard to the alleged difficulty of adopting a wider gauge which would arise from the windings of the railway, he did not think there was anything in the nature of the country to make that an obstacle. There could scarcely be anything worse in that respect than the Todmorden Valley railway, and the trains ran very well on that line; and, generally speaking, he should say, upon any railway where the speed was well understood, and where the rails were not over-canted—which he looked upon as an essential condition—the form of the conical tires used might be made so to guide the wheel frame of the carriages that there would be no sensible friction produced by the difference in the length of the inner and outer rail. These were mechanical points which he did not feel himself authorised to urge so strongly as he did the question of the existence or the non-existence of a break of gauge; and he repeated this opinion very strongly as the result of all he had heard and seen. Therefore, he thought it would be most injudicious to have a break of gauge in the Indian railway system, and he was only surprised to find that the existence of such an evil had ever been seriously entertained.

Captain Douglas Galton, R.E., C.B., said, that having been officially connected with the system of railways in this country, during a part of the gauge controversy, and especially during the controversy on the mixed gauge, he was glad to have the opportu-

nity of offering a few remarks upon the question. He thought it would have been an intelligible policy on the part of the Indian Government to have introduced on to the Indian railways the 4 ft. 8½ in. gauge, and to have altered the whole of the existing lines to that gauge; because, in the event of any great evil happening in India, it would have enabled rolling-stock to be shipped at a moment's notice to replace the destruction of stock on Indian railways; but the Indian Government had already 5,000 miles of railway on a standard gauge traversing the country in all directions, and, under these circumstances, he considered it undesirable to introduce a second extensive network of railways upon a mètre gauge, mixed up with the 5 ft. 6 in. gauge, and forming breaks of gauge on numerous main lines of communication. It was expedient, no doubt, in some cases, to adopt a very narrow gauge to bring down the produce of mines, or factories, or quarries, at a cheap rate to the main line of railway, so as to avoid any transhipment of material at the quarry or the mine; such lines should be cheap tramways for locomotives, which were cheaper to construct and maintain than ordinary roads; and in such cases, each arrangement required special separate consideration; but in this case it appeared that the railways which were proposed to supplant the whole of the existing standard system would, according to the estimates of independent persons, not effect a saving of more than from 6 per cent. to 12 per cent. This would not have been an intelligible course of proceeding had it not been for the explanation of General Strachey, who, he believed, stated, that in the comparative estimates which he submitted to the Indian Government, he had assumed the cost of the standard gauge according to the then standard requirements of the Indian Government, and the cost of the narrow gauge at a new standard of light railway, as proposed by him. They were met in this discussion by being told that they were not conversant with the customs of India, and therefore they were unable to appreciate the effect of a break of gauge in India. He thought if this mode of making comparative estimates was the custom of India they would all agree with him they were not accustomed to it. Now with respect to the question of the cost of these railways it had been so ably discussed by other speakers, that he thought it scarcely necessary further to allude to it, except that no sweeping estimate of this character could be a fair one. Each line required to be looked at separately, in regard to traffic and construction.

As to the question of sidings, the Gauge Commission, in 1846, laid down the axiom that whatever improvements could be intro-

duced on the narrow gauge could be introduced with much greater efficiency on the broad gauge; therefore in comparisons between the carrying powers of the two gauges, it must be admitted that the weight carried per wagon must be in proportion to the gauge; therefore, a train of forty carriages on the broad gauge would carry an amount of goods equivalent to what seventy carriages would carry on the narrow gauge, and consequently the sidings on the narrow gauge must be longer than the sidings on the broad gauge, in the proportion of 7 to 4; and as the cost of the platforms and other accessories of loading would increase in proportion, he thought, instead of estimating the cost of sidings as a proportion of the cost of the railway, it should rather be taken in the inverse ratio of the cost of the railway.

Passing on to the question of the break of gauge, the Author said the cost of transhipping goods at Lahore would be about £850, and he capitalised that at a sum of £17,000. He put the cost of transhipment at 4*d.* per ton, and, as he must be supposed to be well acquainted with the cost of labour in India, that was a figure which they might accept; but there was another important element in the cost of transhipment of goods, that was the injury to the goods. The evidence before the Gauge Commission placed that at 2*s.* 6*d.* per ton, but he would not urge that figure. He would only deal with the one article which the Author and General Strachey both made mention of as being the principal article transhipped at Lahore, namely, salt. Now Captain Galton happened to have some connection with the salt districts in this country, and he had made it his business to inquire of some of the largest manufacturers of salt, in the Midland district, as to the amount of damage to that article from transhipment; and Mr. John Corbett, the manufacturer, who had the greatest experience as to the break of gauge in the transmission of salt, put the amount at 1*s.* per ton, where the value of the salt was 30*s.* per ton; but the cost of the damage necessarily varied with the value of the salt. General Strachey had stated that the value of salt in India varied from 160*s.* to 200*s.* a ton, therefore the Author's figure of £850 would, upon this estimate, rise from £850 to at least £16,000, and his capitalised sum of £17,000 would rise to between £300,000 and £350,000. So much for the commercial question; and with respect to the military point of view, General Strachey seemed to imply that the military question was perfectly immaterial. Now, in the report of General Strachey, Colonel Dickson, and Mr. Rendel, addressed to the Indian Government in September, 1870, they laid great stress upon the military

question, and the Author devoted two pages of his Paper to the same point; therefore he thought it evidently was one which at all events the Indian Government considered as important. Now, he did not think the Author, or General Strachey, had quite appreciated what was the effect of railways upon the movements of an army. The railway enabled them to dispense with forming large magazines near where the army was operating; it enabled them to draw supplies of every sort from almost unlimited distances, and it also enabled them to remove from armies those impediments to their movements, the wounded soldiers, whom otherwise they would have to provide for and to protect. All, who had seen them, admired the excellent arrangements made by the Germans, during the Franco-Prussian war, for the supplies of their army in France. He happened to have been connected with the National Society for Aid to the Sick and Wounded, and he made an expedition along the rear of the German army and saw in detail the arrangements they made for the supplies of the troops. The main feature of those arrangements, and the main thing which enabled them to work with so much smoothness and facility, was the means which they adopted for loading their trains. Each train was specially appointed to a particular division or section of the army, and each train was so loaded that it should convey a portion of all the supplies likely to be wanted, so that if the train itself broke down, or even if a portion of the train broke down, still some portion of the supplies would, at all events, reach the army. Now, he left them to consider what would be the effect of such a mode of arranging their trains and packing their vehicles with a break of gauge. They would have in the first place to change the supplies which had been carefully arranged in a train of forty wagons into a train of seventy wagons; and at the time they were doing this they would have brought down upon them trains of wounded men, some of them incapable of moving hand or foot, who would have to be transferred across the same platform and placed in another train. He was convinced that any one practically conversant with the transhipment of goods or with the loading of trains for ordinary military purposes, would admit that the confusion of such a proceeding would be indescribable, and he thought they would also agree that no money saving could compensate for such a fearful crisis as would then arise. In the matter of the conveyance of the wounded, the Prussians were able to carry four or five wounded men on spring beds with a nurse to attend upon them in a large goods wagon. Now, he did not think any carriage they could place on the narrow gauge would

enable them to carry more than two wounded men with a nurse. If they admitted the axiom that the same improvements could be introduced upon the broad gauge as upon the narrow gauge, it must be assumed that the carrying capacity of the carriages were in proportion to the gauge. Therefore, if they could carry more on the mètre gauge, then they would be able to accommodate proportionately more on the broader gauge; but he felt sure that General Strachey did not appreciate what a large space was required for severely wounded men on a long railway journey. They would, moreover, have to increase the number of nurses, at all events, in proportion to the number of wounded men, and that at a time when every available man was wanted to assist in the warlike operations. General Strachey stated in his observations that one object in introducing cheap lines on the narrow gauge and not estimating cheap lines on the broad gauge at the same time was the difficulty of controlling the expenditure on Indian railways. That seemed to Captain Galton a most astonishing statement, because he had always understood that every detail of construction of Indian railways was submitted to the department of Public Works, over which he believed General Strachey presided, and not only the details of construction, but even the number of trains was fixed by that department. General Strachey also put down as part of the economy, the alteration in the arrangements for constructing lines, that is to say, the construction of the lines under the Government instead of under companies.

Now he thought it would be a digression here to enter into the question as to the economy of Government construction and management of railways as compared with the commercial principle, but he would only say that was not an element that could be fairly imported into this question, because, whatever system could be adopted upon one class of railway could be equally adopted on the other, seeing that the details of construction were in both cases under the direct control of a Government department. In conclusion he must say it was much to be regretted, that the Indian Government, in arriving at a decision on this matter, had had placed before them reports favouring what seemed to be foregone conclusions in the minds of the gentlemen to whom the question was referred, and which reports omitted material facts which would have been adverse to such conclusions. He was glad the question was coming before the House of Commons, and he trusted after the light which had been thrown upon it by this discussion it would be remitted back to the Indian Government, and

that they would then arrive at a more satisfactory conclusion with regard to it.

Mr. H. LEE SMITH said he had devoted much time to the subject, upon which, perhaps, he could give the meeting information that was not generally known; but he was unaffectedly reluctant to monopolise needlessly one minute of its time, which would presently, he hoped, be more profitably employed in listening to more valuable and authoritative opinions. In proof of his sincerity, he would pass very hurriedly over the fact that his figures, as given in the Paper, were painfully misquoted. His estimates for the standard gauge were quoted thus:—

For the Peshawur line	£3,712,440
„ Indus Valley line	3,895,631

But in these sums the Author had, by mistake, no doubt, included two large items on account of maintenance for three years, namely, £85,050 and £128,790, together £213,840, which, being deducted, made the total amount of saving not £912,479, but £698,639. The Author had also entirely omitted to remark that Mr. Lee Smith's estimate for the Peshawur railway on the standard gauge was for an independent line, with banks and cuttings of its own; whilst his mètre-gauge estimate was for a line laid, with the exception of the salt branch, on the metalled road. But what Mr. Lee Smith might have previously said or written on the subject was of little consequence; his present object was to endeavour to meet the Author upon his own ground.

With that part of the Paper which related to the importance of economy, few persons would be disposed to quarrel; the doubtful point was whether the government of India had not adopted altogether too violent a remedy, the effects of which, in the long run, would prove worse than the original disease. It was, however, with the proof of economy, set up by the Author, that they had to deal, and there it was that he appeared to have fallen into error. The Paper literally bristled with fallacies, which Mr. Lee Smith would divide into two classes, the special, and the general; the first having reference solely to the Punjâb lines; the latter—the general fallacy—being the assumption that even if, in the case of some particular line, a saving of £1,000 per mile could be established, the same would hold good over 10,000 miles.

On the Peshawur railway, for example, as half of the metalled road was given up to the line, it would be obvious that the first two items of saving claimed in the Paper, namely, land and earthwork, were entirely illusory.

enable them to carry more than two wounded men with a nurse. If they admitted the axiom that the same improvements could be introduced upon the broad gauge as upon the narrow gauge, it must be assumed that the carrying capacity of the carriages were in proportion to the gauge. Therefore, if they could carry more on the mètre gauge, then they would be able to accommodate proportionately more on the broader gauge; but he felt sure that General Strachey did not appreciate what a large space was required for severely wounded men on a long railway journey. They would, moreover, have to increase the number of nurses, at all events, in proportion to the number of wounded men, and that at a time when every available man was wanted to assist in the warlike operations. General Strachey stated in his observations that one object in introducing cheap lines on the narrow gauge and not estimating cheap lines on the broad gauge at the same time was the difficulty of controlling the expenditure on Indian railways. That seemed to Captain Galton a most astonishing statement, because he had always understood that every detail of construction of Indian railways was submitted to the department of Public Works, over which he believed General Strachey presided, and not only the details of construction, but even the number of trains was fixed by that department. General Strachey also put down as part of the economy, the alteration in the arrangements for constructing lines, that is to say, the construction of the lines under the Government instead of under companies.

Now he thought it would be a digression here to enter into the question as to the economy of Government construction and management of railways as compared with the commercial principle, but he would only say that was not an element that could be fairly imported into this question, because, whatever system could be adopted upon one class of railway could be equally adopted on the other, seeing that the details of construction were in both cases under the direct control of a Government department. In conclusion he must say it was much to be regretted, that the Indian Government, in arriving at a decision on this matter, had had placed before them reports favouring what seemed to be foregone conclusions in the minds of the gentlemen to whom the question was referred, and which reports omitted material facts which would have been adverse to such conclusions. He was glad the question was coming before the House of Commons, and he trusted after the light which had been thrown upon it by this discussion it would be remitted back to the Indian Government, and

that they would then arrive at a more satisfactory conclusion with regard to it.

Mr. H. LEE SMITH said he had devoted much time to the subject, upon which, perhaps, he could give the meeting information that was not generally known; but he was unaffectedly reluctant to monopolise needlessly one minute of its time, which would presently, he hoped, be more profitably employed in listening to more valuable and authoritative opinions. In proof of his sincerity, he would pass very hurriedly over the fact that his figures, as given in the Paper, were painfully misquoted. His estimates for the standard gauge were quoted thus:—

For the Peshawur line	£3,712,440
„ Indus Valley line	3,895,631

But in these sums the Author had, by mistake, no doubt, included two large items on account of maintenance for three years, namely, £85,050 and £128,790, together £213,840, which, being deducted, made the total amount of saving not £912,479, but £698,639. The Author had also entirely omitted to remark that Mr. Lee Smith's estimate for the Peshawur railway on the standard gauge was for an independent line, with banks and cuttings of its own; whilst his mètre-gauge estimate was for a line laid, with the exception of the salt branch, on the metalled road. But what Mr. Lee Smith might have previously said or written on the subject was of little consequence; his present object was to endeavour to meet the Author upon his own ground.

With that part of the Paper which related to the importance of economy, few persons would be disposed to quarrel; the doubtful point was whether the government of India had not adopted altogether too violent a remedy, the effects of which, in the long run, would prove worse than the original disease. It was, however, with the proof of economy, set up by the Author, that they had to deal, and there it was that he appeared to have fallen into error. The Paper literally bristled with fallacies, which Mr. Lee Smith would divide into two classes, the special, and the general; the first having reference solely to the Punjâb lines; the latter—the general fallacy—being the assumption that even if, in the case of some particular line, a saving of £1,000 per mile could be established, the same would hold good over 10,000 miles.

On the Peshawur railway, for example, as half of the metalled road was given up to the line, it would be obvious that the first two items of saving claimed in the Paper, namely, land and earthwork, were entirely illusory.

enable them to carry more than two wounded men with a nurse. If they admitted the axiom that the same improvements could be introduced upon the broad gauge as upon the narrow gauge, it must be assumed that the carrying capacity of the carriages were in proportion to the gauge. Therefore, if they could carry more on the mètre gauge, then they would be able to accommodate proportionately more on the broader gauge; but he felt sure that General Strachey did not appreciate what a large space was required for severely wounded men on a long railway journey. They would, moreover, have to increase the number of nurses, at all events, in proportion to the number of wounded men, and that at a time when every available man was wanted to assist in the warlike operations. General Strachey stated in his observations that one object in introducing cheap lines on the narrow gauge and not estimating cheap lines on the broad gauge at the same time was the difficulty of controlling the expenditure on Indian railways. That seemed to Captain Galton a most astonishing statement, because he had always understood that every detail of construction of Indian railways was submitted to the department of Public Works, over which he believed General Strachey presided, and not only the details of construction, but even the number of trains was fixed by that department. General Strachey also put down as part of the economy, the alteration in the arrangements for constructing lines, that is to say, the construction of the lines under the Government instead of under companies.

Now he thought it would be a digression here to enter into the question as to the economy of Government construction and management of railways as compared with the commercial principle, but he would only say that was not an element that could be fairly imported into this question, because, whatever system could be adopted upon one class of railway could be equally adopted on the other, seeing that the details of construction were in both cases under the direct control of a Government department. In conclusion he must say it was much to be regretted, that the Indian Government, in arriving at a decision on this matter, had had placed before them reports favouring what seemed to be foregone conclusions in the minds of the gentlemen to whom the question was referred, and which reports omitted material facts which would have been adverse to such conclusions. He was glad the question was coming before the House of Commons, and he trusted after the light which had been thrown upon it by this discussion it would be remitted back to the Indian Government, and

that they would then arrive at a more satisfactory conclusion with regard to it.

Mr. H. LEE SMITH said he had devoted much time to the subject, upon which, perhaps, he could give the meeting information that was not generally known; but he was unaffectedly reluctant to monopolise needlessly one minute of its time, which would presently, he hoped, be more profitably employed in listening to more valuable and authoritative opinions. In proof of his sincerity, he would pass very hurriedly over the fact that his figures, as given in the Paper, were painfully misquoted. His estimates for the standard gauge were quoted thus:—

For the Peshawur line	£3,712,440
„ Indus Valley line	3,895,631

But in these sums the Author had, by mistake, no doubt, included two large items on account of maintenance for three years, namely, £85,050 and £128,790, together £213,840, which, being deducted, made the total amount of saving not £912,479, but £698,639. The Author had also entirely omitted to remark that Mr. Lee Smith's estimate for the Peshawur railway on the standard gauge was for an independent line, with banks and cuttings of its own; whilst his mètre-gauge estimate was for a line laid, with the exception of the salt branch, on the metalled road. But what Mr. Lee Smith might have previously said or written on the subject was of little consequence; his present object was to endeavour to meet the Author upon his own ground.

With that part of the Paper which related to the importance of economy, few persons would be disposed to quarrel; the doubtful point was whether the government of India had not adopted altogether too violent a remedy, the effects of which, in the long run, would prove worse than the original disease. It was, however, with the proof of economy, set up by the Author, that they had to deal, and there it was that he appeared to have fallen into error. The Paper literally bristled with fallacies, which Mr. Lee Smith would divide into two classes, the special, and the general; the first having reference solely to the Punjâb lines; the latter—the general fallacy—being the assumption that even if, in the case of some particular line, a saving of £1,000 per mile could be established, the same would hold good over 10,000 miles.

On the Peshawur railway, for example, as half of the metalled road was given up to the line, it would be obvious that the first two items of saving claimed in the Paper, namely, land and earthwork, were entirely illusory.

enable them to carry more than two wounded men with a nurse. If they admitted the axiom that the same improvements could be introduced upon the broad gauge as upon the narrow gauge, it must be assumed that the carrying capacity of the carriages were in proportion to the gauge. Therefore, if they could carry more on the mètre gauge, then they would be able to accommodate proportionately more on the broader gauge; but he felt sure that General Strachey did not appreciate what a large space was required for severely wounded men on a long railway journey. They would, moreover, have to increase the number of nurses, at all events, in proportion to the number of wounded men, and that at a time when every available man was wanted to assist in the warlike operations. General Strachey stated in his observations that one object in introducing cheap lines on the narrow gauge and not estimating cheap lines on the broad gauge at the same time was the difficulty of controlling the expenditure on Indian railways. That seemed to Captain Galton a most astonishing statement, because he had always understood that every detail of construction of Indian railways was submitted to the department of Public Works, over which he believed General Strachey presided, and not only the details of construction, but even the number of trains was fixed by that department. General Strachey also put down as part of the economy, the alteration in the arrangements for constructing lines, that is to say, the construction of the lines under the Government instead of under companies.

Now he thought it would be a digression here to enter into the question as to the economy of Government construction and management of railways as compared with the commercial principle, but he would only say that was not an element that could be fairly imported into this question, because, whatever system could be adopted upon one class of railway could be equally adopted on the other, seeing that the details of construction were in both cases under the direct control of a Government department. In conclusion he must say it was much to be regretted, that the Indian Government, in arriving at a decision on this matter, had had placed before them reports favouring what seemed to be foregone conclusions in the minds of the gentlemen to whom the question was referred, and which reports omitted material facts which would have been adverse to such conclusions. He was glad the question was coming before the House of Commons, and he trusted after the light which had been thrown upon it by this discussion it would be remitted back to the Indian Government, and

that they would then arrive at a more satisfactory conclusion with regard to it.

Mr. H. Lee Smith said he had devoted much time to the subject, upon which, perhaps, he could give the meeting information that was not generally known; but he was unaffectedly reluctant to monopolise needlessly one minute of its time, which would presently, he hoped, be more profitably employed in listening to more valuable and authoritative opinions. In proof of his sincerity, he would pass very hurriedly over the fact that his figures, as given in the Paper, were painfully misquoted. His estimates for the standard gauge were quoted thus:—

For the Peshawur line	£3,712,440
„ Indus Valley line	3,895,631

But in these sums the Author had, by mistake, no doubt, included two large items on account of maintenance for three years, namely, £85,050 and £128,790, together £213,840, which, being deducted, made the total amount of saving not £912,479, but £698,639. The Author had also entirely omitted to remark that Mr. Lee Smith's estimate for the Peshawur railway on the standard gauge was for an independent line, with banks and cuttings of its own; whilst his mètre-gauge estimate was for a line laid, with the exception of the salt branch, on the metalled road. But what Mr. Lee Smith might have previously said or written on the subject was of little consequence; his present object was to endeavour to meet the Author upon his own ground.

With that part of the Paper which related to the importance of economy, few persons would be disposed to quarrel; the doubtful point was whether the government of India had not adopted altogether too violent a remedy, the effects of which, in the long run, would prove worse than the original disease. It was, however, with the proof of economy, set up by the Author, that they had to deal, and there it was that he appeared to have fallen into error. The Paper literally bristled with fallacies, which Mr. Lee Smith would divide into two classes, the special, and the general; the first having reference solely to the Punjâb lines; the latter—the general fallacy—being the assumption that even if, in the case of some particular line, a saving of £1,000 per mile could be established, the same would hold good over 10,000 miles.

On the Peshawur railway, for example, as half of the metalled road was given up to the line, it would be obvious that the first two items of saving claimed in the Paper, namely, land and earthwork, were entirely illusory.

enable them to carry more than two wounded men with a nurse. If they admitted the axiom that the same improvements could be introduced upon the broad gauge as upon the narrow gauge, it must be assumed that the carrying capacity of the carriages were in proportion to the gauge. Therefore, if they could carry more on the mètre gauge, then they would be able to accommodate proportionately more on the broader gauge; but he felt sure that General Strachey did not appreciate what a large space was required for severely wounded men on a long railway journey. They would, moreover, have to increase the number of nurses, at all events, in proportion to the number of wounded men, and that at a time when every available man was wanted to assist in the warlike operations. General Strachey stated in his observations that one object in introducing cheap lines on the narrow gauge and not estimating cheap lines on the broad gauge at the same time was the difficulty of controlling the expenditure on Indian railways. That seemed to Captain Galton a most astonishing statement, because he had always understood that every detail of construction of Indian railways was submitted to the department of Public Works, over which he believed General Strachey presided, and not only the details of construction, but even the number of trains was fixed by that department. General Strachey also put down as part of the economy, the alteration in the arrangements for constructing lines, that is to say, the construction of the lines under the Government instead of under companies.

Now he thought it would be a digression here to enter into the question as to the economy of Government construction and management of railways as compared with the commercial principle, but he would only say that was not an element that could be fairly imported into this question, because, whatever system could be adopted upon one class of railway could be equally adopted on the other, seeing that the details of construction were in both cases under the direct control of a Government department. In conclusion he must say it was much to be regretted, that the Indian Government, in arriving at a decision on this matter, had had placed before them reports favouring what seemed to be foregone conclusions in the minds of the gentlemen to whom the question was referred, and which reports omitted material facts which would have been adverse to such conclusions. He was glad the question was coming before the House of Commons, and he trusted after the light which had been thrown upon it by this discussion it would be remitted back to the Indian Government, and

that they would then arrive at a more satisfactory conclusion with regard to it.

Mr. H. Lee Smith said he had devoted much time to the subject, upon which, perhaps, he could give the meeting information that was not generally known; but he was unaffectedly reluctant to monopolise needlessly one minute of its time, which would presently, he hoped, be more profitably employed in listening to more valuable and authoritative opinions. In proof of his sincerity, he would pass very hurriedly over the fact that his figures, as given in the Paper, were painfully misquoted. His estimates for the standard gauge were quoted thus:—

For the Peshawur line	£3,712,440
„ Indus Valley line	3,895,631

But in these sums the Author had, by mistake, no doubt, included two large items on account of maintenance for three years, namely, £85,050 and £128,790, together £213,840, which, being deducted, made the total amount of saving not £912,479, but £698,639. The Author had also entirely omitted to remark that Mr. Lee Smith's estimate for the Peshawur railway on the standard gauge was for an independent line, with banks and cuttings of its own; whilst his mètre-gauge estimate was for a line laid, with the exception of the salt branch, on the metalled road. But what Mr. Lee Smith might have previously said or written on the subject was of little consequence; his present object was to endeavour to meet the Author upon his own ground.

With that part of the Paper which related to the importance of economy, few persons would be disposed to quarrel; the doubtful point was whether the government of India had not adopted altogether too violent a remedy, the effects of which, in the long run, would prove worse than the original disease. It was, however, with the proof of economy, set up by the Author, that they had to deal, and there it was that he appeared to have fallen into error. The Paper literally bristled with fallacies, which Mr. Lee Smith would divide into two classes, the special, and the general; the first having reference solely to the Punjâb lines; the latter—the general fallacy—being the assumption that even if, in the case of some particular line, a saving of £1,000 per mile could be established, the same would hold good over 10,000 miles.

On the Peshawur railway, for example, as half of the metalled road was given up to the line, it would be obvious that the first two items of saving claimed in the Paper, namely, land and earthwork, were entirely illusory.

enable them to carry more than two wounded men with a nurse. If they admitted the axiom that the same improvements could be introduced upon the broad gauge as upon the narrow gauge, it must be assumed that the carrying capacity of the carriages were in proportion to the gauge. Therefore, if they could carry more on the mètre gauge, then they would be able to accommodate proportionately more on the broader gauge; but he felt sure that General Strachey did not appreciate what a large space was required for severely wounded men on a long railway journey. They would, moreover, have to increase the number of nurses, at all events, in proportion to the number of wounded men, and that at a time when every available man was wanted to assist in the warlike operations. General Strachey stated in his observations that one object in introducing cheap lines on the narrow gauge and not estimating cheap lines on the broad gauge at the same time was the difficulty of controlling the expenditure on Indian railways. That seemed to Captain Galton a most astonishing statement, because he had always understood that every detail of construction of Indian railways was submitted to the department of Public Works, over which he believed General Strachey presided, and not only the details of construction, but even the number of trains was fixed by that department. General Strachey also put down as part of the economy, the alteration in the arrangements for constructing lines, that is to say, the construction of the lines under the Government instead of under companies.

Now he thought it would be a digression here to enter into the question as to the economy of Government construction and management of railways as compared with the commercial principle, but he would only say that was not an element that could be fairly imported into this question, because, whatever system could be adopted upon one class of railway could be equally adopted on the other, seeing that the details of construction were in both cases under the direct control of a Government department. In conclusion he must say it was much to be regretted, that the Indian Government, in arriving at a decision on this matter, had had placed before them reports favouring what seemed to be foregone conclusions in the minds of the gentlemen to whom the question was referred, and which reports omitted material facts which would have been adverse to such conclusions. He was glad the question was coming before the House of Commons, and he trusted after the light which had been thrown upon it by this discussion it would be remitted back to the Indian Government, and

that they would then arrive at a more satisfactory conclusion with regard to it.

Mr. H. Lee Smith said he had devoted much time to the subject, upon which, perhaps, he could give the meeting information that was not generally known; but he was unaffectedly reluctant to monopolise needlessly one minute of its time, which would presently, he hoped, be more profitably employed in listening to more valuable and authoritative opinions. In proof of his sincerity, he would pass very hurriedly over the fact that his figures, as given in the Paper, were painfully misquoted. His estimates for the standard gauge were quoted thus:—

For the Peshawur line	£3,712,440
„ Indus Valley line	3,895,631

But in these sums the Author had, by mistake, no doubt, included two large items on account of maintenance for three years, namely, £85,050 and £128,790, together £213,840, which, being deducted, made the total amount of saving not £912,479, but £698,639. The Author had also entirely omitted to remark that Mr. Lee Smith's estimate for the Peshawur railway on the standard gauge was for an independent line, with banks and cuttings of its own; whilst his mètre-gauge estimate was for a line laid, with the exception of the salt branch, on the metalled road. But what Mr. Lee Smith might have previously said or written on the subject was of little consequence; his present object was to endeavour to meet the Author upon his own ground.

With that part of the Paper which related to the importance of economy, few persons would be disposed to quarrel; the doubtful point was whether the government of India had not adopted altogether too violent a remedy, the effects of which, in the long run, would prove worse than the original disease. It was, however, with the proof of economy, set up by the Author, that they had to deal, and there it was that he appeared to have fallen into error. The Paper literally bristled with fallacies, which Mr. Lee Smith would divide into two classes, the special, and the general; the first having reference solely to the Punjâb lines; the latter—the general fallacy—being the assumption that even if, in the case of some particular line, a saving of £1,000 per mile could be established, the same would hold good over 10,000 miles.

On the Peshawur railway, for example, as half of the metalled road was given up to the line, it would be obvious that the first two items of saving claimed in the Paper, namely, land and earthwork, were entirely illusory.

Mr. Lee Smith had long held the belief that the reduction of the gauge was accepted under some very exaggerated idea of the saving to be effected by the change. Lord Lawrence had stated that, "the average estimated cost of the guaranteed lines was about £17,000 a mile," and the late Lord Mayo had also endorsed that statement. At the same time there were many rumours flying about of "highly-efficient narrow-gauge lines—the railways of the future," at a cost not exceeding £4,000 per mile or £5,000 per mile. Now although he did not mean to argue that either of the eminent statesmen he had named could ever have supposed that any feasible reduction of the gauge would result in a saving approximating to £12,000 per mile, still it was very remarkable to observe the apparent effects of such statements and such rumours upon the minds of some of the foremost men of India.

In a Minute, entitled "The Earl of Mayo as Viceroy of India," Sir John Strachey, a leading Member of Council, reverted to the subject thus:—"The average cost of our guaranteed Indian railways has been about £17,000 a mile. Lord Mayo was satisfied that it was impossible to go on making railways in India at such a cost. He said we must have cheap railways, or none at all; and he strongly supported the proposal that, in constructing new lines the old broad gauge should be abandoned; that, if it were held to be obligatory that the Peshawur line should be constructed on a broad gauge, it would be the duty of Government to say that it could not incur so great an expenditure; whereas the adoption of a narrow gauge would lead to a very large economy." Sir John further stated that, "although he could not enter into these discussions, they were conducted on both sides with great ability."

Now although there might not be any actual proof deducible from this, still, from the expressions "at such a cost," and "so great an expenditure," it did seem a little like a jump to the conclusion that £17,000 per mile, or thereabouts, was the price of a standard-gauge line, and that no expedient could be devised, or, at least, had been thought of, for diminishing that price, save the one mentioned in the very same breath, "the adoption of a narrow guage would lead to a very large economy."

From this he would only argue the probability that narrow-gauge lines, as compared with those on the standard gauge, were at first accredited with a reputation for economy to which they had not been able to, and could not now, substantiate a claim; that in this manner they obtained almost an unfair hold, and were allowed to take firm root, whilst the death of Lord Mayo left the matter in

a somewhat false position, that of a question fairly argued out to the end and irrevocably decided. As for Sir John Strachey's statement, that the question was argued on both sides with great ability, had he said, upon one side, it would surely have been nearer the mark; for, with exception of Mr. Hawkshaw's prophetic warning, which was sent along with the Committee's report, to the Government of India, there did not appear to have been a single protest lodged against the reduction of the gauge or a counsel engaged, or witness called to speak a word in defence of the standard gauge.

They now heard of the two divisions of a narrow-gauge railway up the Indus Valley, described by the consulting engineer to the Government of India as 'a surface line,' and estimated to cost (exclusive of one or two large bridges) about £5,100 per mile to £6,000 per mile—average, £5,550 per mile, or, deducting rolling-stock, say £5,000 per mile. Was this considered a great result? Was breaking the gauge the only expedient by which this figure could be come down to? Why, even in his poor Indian practice, Mr. Lee Smith had done much better than that! He had before him the 'completion statements' of a district of the East Indian railway, 81¼ miles long, of which he had responsible charge. It was executed 'departmentally,' that was without the aid of large contractors, and had cost, taking the whole length, £6,160 per mile; but as 37¼ miles of this were constructed under the heavy troubles and disadvantages of the great Mutiny, he thought he might fairly cut them out, and speak only of the remaining 44 miles, which were commenced after the Mutiny, and finished in fair time—three years, he believed, or as fast as they could get the permanent-way materials. The cost of this division was exactly £5,370 per mile, which included earthwork, ballast, bridges and culverts, level-crossings, permanent-way, telegraph, stations—including the fair proportion of a large locomotive-changing-station in the centre of the division—everything complete, except land and rolling-stock. He had also added—not knowing the precise amount—10 per cent. on account of Engineering expenses. Some of the rails weighed 78 lbs. per yard, and some 82 lbs. per yard. He did not now remember which were used upon this particular division; but assuming the lighter and they had this section of the main line of the East Indian railway—with which, on the score of stability, no man need be ashamed to have been associated—completed, upon the 5 ft. 6 in. gauge, with 78-lbs. rails, for £5,370 per mile, against the estimated cost of a mètre-gauge surface line up the Indus Valley, with 40-lbs. rails, at £5,000 per mile. Nor was

there any advantage owing to proximity to the sea; the land-transport was not less than 800 miles; that was up to the neighbourhood of Agra. And if General Strachey wished to know the price of the rails—though Mr. Lee Smith regretted being unable to state precisely—he believed it could not have been very much below that quoted lately by the consulting engineer to the Government of India for state railways, for his 40-lbs. rails, namely, £8 per ton free on board in England. Mr. Lee Smith almost forgot to mention, as being perhaps worthy of note, that the embankments of the standard-gauge line, of which he had given the details, were 34 ft. wide at formation-level, instead of 10 ft. 3 in., the estimated formation width of the Indus Valley line.

But no English Engineer, however great his experience, could, with any propriety, have volunteered his opinions in the face of the following Resolution by the Viceroy in Council, in accordance with which, Mr. Lee Smith believed, some American Engineers were specially invited to India. He would not read the whole of the decision, unless it was their wish, but content himself with the following extract:—"The time has come when India should cease to lean exclusively upon English Engineers in dealing with its railways."

Here he might perhaps be permitted to remark, that he felt it a little ungenerous on the part of his friend General Strachey that he should have included him in his censure, or at least not exempted him from his criticism upon the Engineers of the Indian lines, who never "suggested the construction of light or cheap lines, or admitted that they were possible." General Strachey might perhaps have forgotten that, as Secretary to the Government of India in the Public Works Department, he had sent Mr. Lee Smith in his own handwriting the flattering assurance that "Government was perfectly satisfied with the Chief Engineer of the Peshawur line, who had cordially and loyally accepted the general policy of the Government;" which then, as now, Mr. Lee Smith understood, not as a tribute to his unvarying good behaviour generally, but as an acknowledgment that he was devoting all his poor energies to contriving how to carry out his work to the best advantage of Government. The reduction of gauge was then unthought of. It was suggested to him for the Peshawur line by an amateur; but if it had been seriously proposed to him by Government, he would then, as now, have given his decided opinion, supported by his reasons, that it was wholly unnecessary, and extremely unwise. To say that he did not think of or suggest light permanent ways, was a mistake. Seven years

ago, in his first Report on the Peshawur line, he stated that, although 50-lbs. rails "might be equal to the present (then) requirements of the traffic, experience had proved there was no real economy in reducing the rails below the ordinary standard, and that, in his judgment, the heavier permanent way would prove the better economy in the end;" an opinion of which at the present day he was not greatly ashamed.

These, however, were trifles hardly worth mentioning. The serious part of General Strachey's remarks was that wherein that officer referred to figures. Was it not almost time for some powerful remonstrance, when they found the highest, nay, the only Indian State railway officer in this country, who inaugurated, and still alone led the way in the break of gauge, two years after that step had been taken, talking in this strain:—"Those estimates were utterly worthless for the object in view." "Rejecting those figures as wholly inapplicable, General Strachey asserted that the financial advantage, that had in fact been secured, was very great." "The saving on permanent way would amount to about £350,000, and on the bridges perhaps to £250,000, or together £600,000." "On the whole he considered that the total economy might be about three-quarters of a million. The 490 miles of the Indus Valley railway would give a saving of not less than £500,000 on the permanent way, and probably as much more on other items, or, in all, about one million." "But," he added, "the character of the works was not yet sufficiently known to admit of any very precise statement being made as to this line." Fortunately Mr. Lee Smith had the precise information, in the shape of the latest estimate by the officiating Chief Engineer, given in the most minute detail, from which Mr. Lee Smith, at least, had been able to arrive at somewhat less vague results. He would state the exact additional cost of making the permanent way of the Indus Valley railway fit to carry both the carriages and the engines of any, or all the other Indian lines. This he had worked out, to decimal parts of a rupee, from the prices given in an estimate sent to the Secretary of State by the Government of India, no further back than November last, and if they would divide General Strachey's £500,000 saving by two, and add £690 to the result, they would get the actual saving within a few shillings.

As for the bridges on the Peshawur line, he was in a position to speak from facts which he would defy any person to contradict. He himself had designed the girders for that line for both gauges, both standard and mètre, and had personally superintended all the

details of the drawings down to the smallest rivet. Had General Strachey forgotten, when he talked about a saving of 30 per cent. to 40 per cent. on the cost of the ironwork of all bridges, that the smaller girders for the first 100 miles of the line were designed, constructed, and sent out of the full standard-gauge strength? Had he also forgotten that the larger bridge girders upon the mètre gauge which had been made and shipped were not narrower, nor so narrow, but—from having to carry a common road carriage-way in addition—actually 18 in. wider between the hand-railings than those which he had approved and passed in Simla and Calcutta for the standard gauge? But, not to enlarge too much upon this point, he would simply inform the Meeting that he had made at least a dozen or eighteen different designs for the bridges in question upon three different gauges, and of every conceivable span, striving in every possible way to cut down the quantity of ironwork to the lowest limit compatible with safety; that he had still in his possession all his sketches, figures, and quantities, and that if they wished to know the exact saving between the standard-gauge design and the mètre-gauge one adopted, constructed, and shipped, they must again take some liberty with General Strachey's figures. It was not 40 per cent., it was not 30 per cent.; but if they would divide the latter figure by ten they would then know exactly what the saving was. He would challenge investigation. The drawings were quite open to the inspection of any one who would seriously take the trouble to question his statements.

No one, however, who read the published official documents could entertain much doubt that the Government of India had made up its mind to the break of gauge, and accepted the necessity of it as a foregone conclusion. Looking for one moment at the facts. The question was formally referred to a committee, and a special subject or theme was set for them upon which to base their report, namely, the Indus Valley and Peshawur railways, and this theme, indeed, was still further narrowed to the former of these lines alone—the Indus Valley—as Government admitted the exceptional case and position of the Peshawur line in these words:—"We have no hesitation in saying that were it a question of the section between Lahore and Peshawur alone, we should at once dismiss from consideration all idea of anything but a standard-gauge line." But although the result of this committee's deliberations, read in the light of the Secretary of State's orders for the alterations of the Scinde and Punjâb railways, were such that any schoolboy who added the figures together could have seen, at a glance, that the proof of economy had broken down, was there any re-considera-

tion or hesitation? Apparently not the slightest. The Government of India would seem, as he had before surmised, to have looked upon the economy as a foregone conclusion, and to have proceeded calmly to break the gauge—in spite of Mr. Fowler's dissent, and the failure on the part of the rest of the committee to prove any appreciable saving—as they alleged:—"We are satisfied that the economy likely to be obtained from the adoption of the narrow gauge will justify our accepting the break of gauge at Lahore, with such inconveniences as it involves."

Here he would beg to explain, for the information of those who might not have seen the Report which he quoted from, that by Mr. Fowler's estimate the difference of cost between making the two lines, he was alluding to, upon a gauge of 3 ft. 6 in.—that was $2\frac{5}{8}$ in. wider than that now adopted by the Government of India—inclusive of the alterations ordered by the Secretary of State, and completing them upon the standard gauge with 42-lbs. rails, amounted to £17,668 in favour of the latter. And to check this roughly, he would take Mr. Thornton's figures:—
Indus Valley line, 493 miles × £1,000 per mile = £493,000 saving.
Alterations of Scinde and Punjâb lines (ordered by Secretary of State, estimated by Messrs. Strachey, Dickens, and Rendel), £520,000 loss.
Saving £493,000: loss, £520,000. Balance, still in favour of the standard gauge, £27,000. Were such results, emanating from such authorities, even if wildly erroneous, not worthy of searching investigation? Were they not almost startling enough to induce Government to pause before crippling for ever those two lines, admitted to be "of as great strategical importance as any yet to be made in India?" But granting, for the sake of argument, that the Author's figures were quite correct, that the reduction of the gauge between Kurrachee and Peshawur would save altogether £530,000, he would show at what real sacrifice, nay peril, this saving was to be effected.

The line, it would be observed, was cut off, absolutely shut out, from communication with any other line in India, and must, therefore, rely entirely upon its own resources in the matter of rolling stock, which ought, therefore, to be provided on a scale of unusual and extraordinary liberality. But instead of this, incredible as it might appear, the stock was actually estimated at the miserable rate of one engine and thirty vehicles for every thirteen miles, which the advisers of the Government of India stated to be calculated for, and to be sufficient for, two trains a day each way. Now, he cared not by whose testimony they elected to decide—Mr. Thornton's or General Strachey's—for by either of them he

would show that these calculations and arrangements were fallacious, if not almost unfair to the policy and judgment of the late Viceroy, who agreed to the break of gauge, on, they might assume, the plain and obvious understanding that his narrow-gauge line was at least to be able to stand by itself, or, in other words, to be stocked upon such a scale as would meet his estimate of any possible emergency.

It had been said by Lord Mayo that, with regard to the power of transport, the resources of the narrow gauge were such, that nearly 20,000 infantry, with baggage, camp equipage, and ammunition could be placed at Rohree from Lahore in one week; and again, he wrote of the possibility of "throwing 40,000 men in a fortnight on any point of the frontier from Lahore," which he had not the slightest doubt could be done, provided they had the rolling stock. But how was his Lordship's policy about to be carried out by those to whom that duty had been confided? General Strachey and his colleagues on the Committee, Messrs. Dickens and Rendel, said that 30 vehicles of the standard gauge were equal in carrying capacity to 54 of the narrow gauge.

General STRACHEY explained that their estimate was based upon a 2 ft. 9 in. gauge.

Mr. H. LEE SMITH acknowledged the correction; but the carriages for the mètre gauge were only 6 in. wider, and the length was unchanged. Again, that 200 carriages of the standard gauge were required for the transport of 1,000 fully equipped men, with their proportion of artillery, cavalry, cattle, camp equipage, and stores; therefore, taking the same proportion, that 360 narrow-gauge vehicles would be required for this duty; that each train might be made up of 30 carriages, consequently ($\frac{360}{30}$), that 12 trains a day would transport 1,000 men, fully equipped, as before described, from Lahore to Peshawur, which would be equal to 7,000 men in one week. These were the calculations of the Gauge-Committee, but the Author calmly told them that he would take up 11,000 men, not 7,000 men, in a week, and with rolling stock for 2 trains a day instead of for 12 trains a day!

Mr. THORNTON denied that he had said anything of the sort.

Mr. H. LEE SMITH begged to refer to the Paper. It distinctly stated that 11,000 men could easily be moved from Lahore to Peshawur in a week.[1] Mr. Lee Smith would as positively assert,

[1] "Now, although the provision of rolling stock for the future Punjâb lines is intended to be much below that of most existing Indian railways—although, while, according to Mr. Hawkshaw, the average complement of the latter is about

that the sum allowed in the Government estimates for engines and vehicles was no more than sufficient to provide rolling stock for 2 trains a day.[1] He had not lost sight of the arrangement proposed by Government to obviate this little difficulty, namely, that of "concentrating their rolling stock, upon occasion," in some threatened locality. This plan, although it might cause some inconvenience to the ordinary traffic, would no doubt meet the military emergency, which was the main consideration; but there was one element required to insure its successful working, and that was the existence somewhere, in sufficient quantity, of rolling stock to concentrate. There could not be much to come and go upon between Lahore and Mooltan, as that division was to depend entirely for its only concentratable stock upon the sale of a portion of the existing broad-gauge stock, the Author having ruthlessly disallowed every penny put aside by Mr. Fowler for the purchase of a few extra narrow-gauge vehicles. The same arrangement, it might be supposed, as the Author had made no allusion to it at all, was to be effected upon the Scinde line, between Kurrachee and Kotree; but it might be granted that both those divisions were, somehow or other, to be stocked likewise for 2 trains a day. Now, suppose Peshawur to be threatened, and the whole rolling-stock to be withdrawn from the Indus Valley—which, from Lahore to Kurrachee, was three times the length of the Peshawur line—and concentrated at Lahore, this would provide sufficient engines and vehicles for 6 trains in addition to the 2 trains already provided, or in all for 8 trains a day. And rejecting the estimate of Messrs. Strachey, Dickens, and Rendel of 7,000 men per week, carried by 12 trains a day, accept

---

one engine, with vehicles in proportion, for every five miles, the Government authorities are of opinion that for the lesser traffic of the Punjâb one engine and thirty vehicles for every thirteen miles may possibly suffice—yet, even with rolling stock at this exceedingly low rate, it has been demonstrated by careful and minutely detailed calculations that, in the course of a week, 12,000 combatants of all arms, infantry, cavalry, and artillery, fully equipped, and with a month's rations, could easily be removed from Lahore to Sukkur, or 11,000 from Lahore to Peshawur, or three corps of 4,000 each, one from Lahore to Peshawur, a second from Lahore to Sukkur, and a third from Kurrachee to Sukkur."—*Vide* ante, p. 16.

[1] Actual allowance of rolling stock, according to preceding extracts:— "One engine and thirty vehicles for every thirteen miles," or, 1 engine to 13 miles. 2·307 vehicles per mile.

Rolling stock required for "two trains each way per diem," *vide* Messrs. Strachey, Dickens, and Rendel's Report on the Gauge question, Parliamentary Return, page 53:— 1 engine to 8·56 miles. 2·336 vehicles per mile.—H.L.S.

the Author's less comfortable allowance of 11,000 men in a week, carried by 8 trains a day — then only, further, supposing the Russians to be smart enough to have been making a feint of coming down the Khyber, the real attack being by the Bolan Pass, or (as they would probably come in considerable strength, if they should think of coming at all) suppose them to appear in great force by both of these passes, our 11,000 troops were being sent up to Peshawur, and there would be the great military line from Lahore to Kurrachee—" of as great strategical importance as any yet to be made in India," 812 miles long, with neither an engine nor carriage to run on it![1] But the more this part of the question was looked into, the more uncomfortable it would be found. The narrow-

[1] What is to be the total quantity of rolling stock between Kurrachee and Peshawur? What quantity of stock would be required for the conveyance of 11,000 men in a week from Lahore to Peshawur? Provision is to be made at the rate of 30 vehicles for every 13 miles, whilst on the two divisions where the standard gauge already exists the Author suggests supplementing the broad-gauge stock "by a quantity of mètre-gauge rolling stock for use on a mixed gauge." Presumably, then, half the stock on these divisions will be broad gauge, and half narrow gauge, or 15 vehicles of each for every 13 miles.

If so, the total mètre-gauge stock, or concentratable stock will be:—

Between Kurrachee and Kotree	105 miles at	15	vehicles per	13 miles	=	120	vehicles.
„ Kotree and Mooltan	493	„	30	„	„ =	1,140	„
„ Mooltan and Lahore	214	„	15	„	„ =	240	„
„ Lahore and Peshawur	270	„	30	„	„ =	630	„
Total number of mètre-gauge vehicles between Kurrachee and Peshawur						2,130	„

Coming now to the second question:—The Gauge-Committee states (page 39 of the Parliamentary Report) that, on the Peshawur line, 12 trains up and 12 trains down per diem, each consisting of 30 standard-gauge vehicles, or 54 narrow-gauge vehicles, would represent the limit of the continuous working power of the line, and would suffice for the conveyance of 1,000 men fully equipped, with their proportion of artillery, cavalry, cattle, camp equipage and stores, per diem, or 7,000 men per week, from Lahore to Peshawur.

Then, in exactly the same proportion, if 7,000 men per week require (24×54) 1,296 vehicles, 11,000 men per week will require 2,036 vehicles, and the effect may be thus:—

Total mètre-gauge stock on the whole line, as shown above	2,130	vehicles.
Total ditto, which may require to be concentrated north of Lahore	2,036	„
Balance then available for the line from Lahore, southwards, to Kurrachee	94	„

94 carriages to 812 miles of line, and no allowance made for any being in the shops or under repair! It must surely be admitted that this is "cutting it rather too fine," and that the provision of stock at the rate proposed, of 1 engine and 30 vehicles for every 13 miles of line, would, in the event of an emergency, prove lamentably insufficient. —H.L.S.

gauge line might, for aught he knew, be equal to the transport of 11,000, or 20,000, or more, troops in a week, if amply supplied with engines and carriages, but certainly not unless it was so provided; and although rolling-stock for 2 trains a day might be more than sufficient for the ordinary traffic, it was absurdly insufficient for a possible military emergency. What was more, he rather thought the Government of India began to have its doubts upon the subject, as he had found, in more than one passage of the Government Reports, a little hint that the rolling-stock might have to be increased to the capacity of 4 trains a day—in plain words, an estimate for doubling it. This, at one fell swoop, would swallow up the whole of the Author's hardly earned saving of £530,000, would leave him, even then, with his line stocked at a lower rate than the neighbouring railways, and with the comfortable reflection that he was cut off from communication with any of the other lines, and had broken the gauge for nothing! He sincerely believed that the Government of India, and perhaps even the Author, began to think it would have been as well to leave the Punjâb lines alone, and, as they could not recall the past, even if that £530,000 of saving were real, which he meant presently to show it was not, to have let it go in completing the 5 ft. 6 in. gauge 'folly' upon which their predecessors had invested, or sunk, £90,000,000 sterling, and contented themselves with a total saving of £9,470,000 instead of £10,000,000.

If there were a grain of sense in this argument he had two suggestions to offer which he would freely place at the disposal of Government. The first was, that if they could afford to spend £7,000,000 in constructing these lines up the Indus Valley to Peshawur but not the additional £530,000 required to make them efficient—taking the Author's figures—the Government had better abandon the idea of a railway altogether, and keep the £7,000,000 in their pocket. After the eloquent description given by the Author of the timely notice we were sure to have of any aggressive movement on the part of Russia, and the perfect deliberation with which troops could be massed at Lahore, ready for projection upon any part of the frontier, he should be disappointed, although that gentleman was not in the habit of adopting his suggestions, if he had not at last placed one at his disposal of which he might be able to approve. But if that would not do, his second suggestion—which he believed would be approved by the entire community of the Punjâb, and by all the military authorities in India, and in England—everywhere, in fact, except perhaps in Russia—was simply to devote the £7,000,000 required

for the narrow gauge to the completion of the standard gauge in the Indus Valley, and its extension in the direction of Peshawur for 180 miles above Lahore, up to the great military station of Rawal Pindi, or for 56 miles further, if they pleased, up to the Indus, at Attock, which some people considered was really our proper boundary. By stopping short the railway at even the latter of these two points the cost of a bridge over, or tunnel under, the Indus, and of 44 miles of line would be saved, which together would certainly amount to more than £530,000. Would not this be a better way of saving the money, as the mistake then would not be an irretrievable one? Then, too, they might further economise to any extent in the matter of engines and carriages, putting on just barely sufficient to carry the ordinary, very limited, commercial traffic—2 trains a day—1 train a day—1 train a week if they liked; but relying with confident security, in the event of a military emergency, on the entire rolling-stock of the rest of India. He was certain this suggestion only required looking into to recommend it to the notice and approval both of the Viceroy and of the Commander-in-Chief.

In stating that this great political line, from Kurrachee to Peshawur, would, by the break of gauge at Lahore, be absolutely cut off and isolated from all the other railways of India, he was aware that the Author did not agree with him, because that gentleman had mentioned, as worthy of special notice, that, "the connection of the Indus Valley railways with those of Rajpootana is a project regarded by the Indian Government as one which may deserve to be undertaken at some future period;" and he hinted, but for an excess of generosity on his part, that, were he disposed to be hard on the standard gauge, he might debit that scheme with his £1,000 a mile saving, over the whole length of this connecting link, which, with the line up to the Bolan Pass, he aggregated at "scarcely less than 400 miles."

In this estimate Mr. Lee Smith submitted that the Author was doing his case injustice by his extreme moderation. The length of the Bolan Pass line alone, up to Dadur, was 180 miles, and upon this he had claimed, and credited himself with, his £180,000, leaving therefore only 220 miles to complete the connection between the Indus Valley and the Rajpootana railways. But the actual length of this deserving project of the future was estimated by the Government of India,[1] not at 220, but at "about 410 miles."

[1] *Vide* Supplement to "Gazette of India" of December 30th, 1871, page 1,738, paragraph 14.

Why then had the Author of the Paper claimed no more than £180,000? and only hinted that he might have claimed £400,000?

Why had he not asserted his right to (180 + 410 = 590 miles × £1,000) £590,000? Was it pure generosity? or had he some slight misgivings as to the legitimacy of the claim? No one, except the Author, could profess to know, but a very superficial investigation of the facts would lend a strong air of probability to the latter surmise.

The real meaning and object of this line was to supply one solitary channel of communication between the Indus Valley and the Rajpootana narrow-gauge system, which would neither be required, nor, Mr. Lee Smith asserted, would it have been dreamt of, for the next hundred years, if the standard gauge had been maintained between Kurrachee and Peshawur. The line in question would not in any way promote one of the greatest, if not the chief, object of the through lines, in—to quote the words of the Secretary of State's despatch—"abridging the distance from Bombay to Lahore," or, in "giving a new approach to Lahore from the sea." On the contrary, it would lengthen the journey between Bombay and Lahore, either of private individuals, who might have time enough on their hands to prefer that route, or of troops, by just 310 miles.

However, as they had heard, on such high authority, that the line was actually spoken of as one which might hereafter be undertaken, such a probability could not be ignored, and he would therefore earnestly beg the attention of the meeting to the financial aspect and probable commercial results, of such a project. Lord Lawrence wrote that "a line might be contemplated from Kotree, *viâ* Luckput, through Cutch, to Ahmedabad," but the Government of India would appear to have rejected that suggestion, as he found it stated in a later despatch of October, 1871, that "this connecting link might be made from Ajmere, *viâ* Jodhpoor and Jeysulmere, to Rohree, length about 410 miles," and he had not the slightest doubt that it might. Indeed, after rejecting the route proposed by Lord Lawrence, the choice left with the Government of India was a very wide one, and about as eligible as that supposed to lie between the frying-pan and the fire. He admitted that he had never been in Kattywar or Cutch, and that he did not speak from personal observation, but he had read up the best authorities he could find on the subject, and had noted the following interesting particulars of the country this line would have to traverse, or through which it would have to thread its way.

Commencing from the south, the "Great Runn of Cutch" was

described as "a vast salt morass, flooded in the monsoon by sea-water blown into it," the only other features which he had noted, but which were of little importance from a traffic manager's point of view, being that it is much frequented by wild asses, whilst in the dry season it swarms with flies.

Scinde was described as "shut in between a vast desert on the east and a lofty mountain range on the west." In the southern portion of it was the "Little Desert," a proud distinction, preventing, it might be hoped, the danger of its being confounded with its immediate neighbour on the north, which rejoices in the name of the "Great Desert."

Of Ajmere, still further north, it was said, "the general appearance is sufficiently dismal, a considerable portion of it being absolute desert, whilst the last 100 miles south-west of Bahawulpoor is wholly destitute of water, vegetation, and inhabitants," and Jeysulmere, upon which the mantle of choice seemed to have fallen, was said to be "surrounded by a great desert, of which it may almost be described as an integral portion." Such were the descriptions given of the inviting regions into which the Government of India felt itself bound to contemplate the construction of a railway; bound, moreover, solely by the proposed break of gauge upon the Indus Valley system. For, were it not a matter of sheer necessity to provide some channel for the interchange of carriages or the supply of reserve stock from Central India, he confidently submitted that a railway 410 miles long, through such fearful districts, would stand as much chance, and no more, of being taken up, as a line through the centre of the Great Desert of Sahara.

After the picture drawn, too, of the injustice, or the hardship, at least, of forcing railway blessings upon people at a price beyond their market value, he would be surprised if the Indian tax-payers did not keep a watchful eye upon any steps which might be threatened for the commencement of this truly dismal project; and meanwhile, he would only submit that, instead of pretending to claim £410,000, or even £220,000, as a saving, which would result from making this a mètre, instead of a standard, gauge, the saddle should be put on the right horse, and the whole cost of its construction (at say £5,000 a mile × 410 miles = £2,050,000) should unquestionably be debited to the former, the shortcomings and weaknesses whereof formed the only grounds upon which such a line could ever be deemed necessary, or could stand a chance of being undertaken.

All this while, he had been proceeding on the assumption that

the Author had, by some of these more than doubtful expedients, established a claim to a saving of £530,000, which, however, Mr. Lee Smith now confidently repudiated. General Strachey's figures were not, as he thought he had already shown, in a sufficiently mature state to be attacked. That officer might easily, had he been so minded, have given them quantities, weights, and prices, and allowed them a fair opportunity of examining them; but if he had done so it could easily have been shown that his estimates were unsupported by reasoning or facts. Mr. Lee Smith had also, he believed, proved that the original attempt on the part of the committee to establish any appreciable economy by reducing the gauge in the Indus Valley had broken down. Under these circumstances, and always supposing that Government condescended to argue the question, and not merely to stand upon its right to do what it pleased about the gauge, without reference to anybody's figures or opinions, it was perfectly evident that a new case had to be made out, a task which the Author accordingly proceeded to execute in a vigorous and independent manner. He threw over the Secretary of State's orders as regarded laying a third rail on the Scinde line, and decided to reduce it to a mètre gauge, whilst the opinions of the Government of India as to reserve rolling-stock for military emergencies were treated with sublime indifference.

To the first of these proposals, namely, to reduce the gauge of the line between Kurrachee and Kotree, probably the Scinde Railway Company might have something to say; but how about the second proposal, to dispense entirely with the extra rolling-stock required by the dislocation of the gauge?—the necessity for which had been recognized, as far as he could learn, by every person who had ever been asked for or had given an opinion on the subject, excepting by the Author.

He found, for example, from official documents, that the Viceroy in Council—who was generally allowed to have a voice in the matter,—had "no hesitation in adopting the conclusion that this Peshawur railway should be designed and carried out, so as to ensure the smallest expenditure that will provide a thoroughly permanent and useful iron road, that can be traversed by the ordinary locomotive and wagon stock in use on the Punjâb and East Indian railways at a low speed."

If this were not sufficient he could quote the opinion of the Secretary of State, who first gave his assent to the construction of this railway, namely, "that a second class line, such as has been proposed by Colonel Strachey and others, would fail to secure

any very important advantage," and could give five other extracts from the Government despatches, all fully recognizing the importance of being able to draw upon the other great Indian lines for reserves of stock; which, however, the Author not only disdained, but declined to allow one penny for extra narrow-gauge stock, which would, to some extent, have made up for the loss of use of the broad-gauge stock.

It was certainly a bold theory to advance that, "for the Lahore-Peshawur section, the cost of providing rolling stock sufficient for ordinary traffic would be the same whether the gauge were broad or narrow," for that was simply to say that a narrow-gauge railway, isolated from all the other lines of India, stocked at the miserable rate of 1 engine and 30 vehicles for every 13 miles, would no more require any extra stock, and would therefore, in other words, be as reliable and efficient as a standard-gauge railway would be when in free communication with some 5000 miles or 6000 miles of fully stocked line at its back; but he could not express his opinion of such sophistry without departing from his good intention to speak with becomin respect of a favourite Government project. Had he known the ground the Author intended taking up Mr. Lee Smith could have offered him rather a good suggestion, namely, that he should adopt the more decided opinions upon a break of gauge, recently laid down in a publication entitled, "The Battle of the Gauges," and reproduced in the "Times," of the 17th February, 1873, in an extremely flattering review of that work. The following were the exact words:—"When a long journey has to be continued over the lines of different companies, a break of gauge where these lines join would be a positive saving." Now that was something like an argument! and if it were sound Mr. Lee Smith was doing a service in calling prominent attention to it. What a chance for Government when they took over the Irish railways! And as no opportunity of effecting a 'positive saving' should be neglected, a few judicious breaks would probably be introduced into the English railway system as well. But meanwhile, until this theory was more fully developed and explained, he suspected the Meeting would not be driven from its old-fashioned idea that a break of gauge was a source of delay, loss, and grave inconvenience. As for the Peshawur line, the rough common-sense idea would be, that instead of narrowing the gauge at Lahore the funnel ought there to be widened, or that the desired saving might be better effected by retaining the standard gauge and economising in the item of stock.

But all these suggestions were overruled; a sum of £6,000,000 or £7,000,000 was to be expended on the construction of a line declared to be "of the highest political importance," and "of as great strategical importance as any yet to be made," and which, to be kept down to that figure, to save £530,000, was to be stocked on literally the starvation principle, contrary to the wishes of even its own promoters! He thought the Meeting would unanimously agree with him that the game would not pay for the candle, and that to expend £6,000,000 or £7,000,000 upon a half useless undertaking would be a criminal waste of money.

A very curious argument was advanced against borrowing rolling-stock if the standard gauge had been preserved. It was stated in the Paper that:—"Heavy-line engines could not be permitted to travel upon their light rails; so that, in order to be able to utilize on emergency the borrowed vehicles, it would be necessary always to maintain on the Punjâb lines a duly-proportioned number of reserve engines to haul them, the enormous expense of which would of itself be an insuperable objection to borrowing."[1] This was clearly an admission that the traffic superintendent on an emergency might find himself short not only of wagons and carriages, but of engines as well! Admitting the possibility that he might require to borrow five shillings, he allowed an insurmountable barrier to be placed between himself and his friendly neighbour, who said:—"If ever you should find yourself in such a fix, you may rely on me for half-a-crown." But why did the Author build all this part of his argument on the supposition that the standard gauge must of necessity be a light line, and shut his eyes so resolutely to the possibility of using a heavier rail? A very fair start in this direction had actually been made, as rails intended for the Peshawur line, weighing 60 lbs. to the yard and sufficient to lay 100 miles, had already been sent out. What the Government of India proposed to do with these rails he did not know. They had told the Secretary of State that "they can be used elsewhere, probably on the Rajpootana line," but as that was also to be a light mètre-gauge line the advantages of the suggestion were not very apparent. Disregarding, however, such experience as Mr. Harrison's of what he had done with 40-lbs. rails, when he had run the traffic between England and Scotland over them for about four years—had the Author reckoned the additional cost of making these Punjâb lines fit to carry, not only the vehicles, but also the engines, of the

[1] *Vide* ante, p. 15.

neighbouring lines? This could probably be done most cheaply in the first instance by increasing the number of sleepers and putting them closer together, but a better plan would be to increase the weight of the rails up to 50 lbs. per yard. He had estimated what it would cost to do that upon the Indus Valley line, carefully worked out at the prices quoted in the officiating Chief Engineer's estimate, dated only a few months back, and allowing for the extra quantity of ballast and for the additional length of sleepers, he found it would be just £250,690. And upon the Peshawur line about—for in this case he had not the Government rates[1]—£133,650. These were not large sums to pay for insuring beyond the possibility of doubt the efficiency of two lines, upon which, almost entirely for strategic reasons, it was deemed necessary to spend £7,000,000.

One word more about the rolling-stock. The Author disallowed the amount claimed by Mr. Fowler and everybody else, for working through traffic on the narrow gauge between Mooltan and Lahore, on the ground that the balance of broad-gauge stock on that division, which other lines had not been polite enough to buy, would remain to supplement the narrow-gauge stock which he proposed to put on. Now what did this disallowance involve? Something very like a second break of gauge at Mooltan! The traffic, it was to be observed, was to come up by a single narrow-gauge line to Mooltan, but at that point it was to be split up and put into the stock of two different gauges!

Why, in addition to all the other perfect arrangements for the harmonious working of their state lines, Government would have to rear or design a special race of porters and station-masters, as no ordinary man could possibly be expected to solve the problem presented to him on the arrival of each train—that of filling the broad-gauge trucks with 1$\frac{3}{5}$ths of the load of two of the narrow-gauge ones, and *vice versâ!*

The thing, of course, was a farce; it could not possibly work for a month; the third rail would be of no more practical use than a third leg to a pair of breeches; and the result would be that one of the present rails of the Punjâb line would speedily be thrown out of gear, leaving the bulk of the traffic for conveyance on the mètre-gauge line, with the latest mechanical novelty, a 68-lbs. rail on one side, and a 40-lbs. rail on the other.

[1] Mr. Lee Smith, however, had taken the price of iron delivered on the line at £20 10s. per ton, instead of £16 10s. as quoted in the estimates of Messrs. Fowler, Strachey, Dickens, and Rendel, and the sleepers at the price at which Messrs. Brassey, Wythes, and Henfrey, had been buying them.—H. L. S.

To come now to the Indus Valley line, which was declared by the Government to be "of as great strategical importance as any yet to be made," he maintained that it was being made on the wrong side of the river, and he had much more weighty testimony on this point to produce. Lord Lawrence said it should be "on the other side of the Indus to that occupied by the main line from Kurrachee to Kotree;" whilst Lord Napier of Magdala, whose opinion, as Commander-in-Chief, upon a strategical line was surely of the greatest importance, had recorded in a separate special minute, that he dissented from the proposed adoption of the right-bank side. He had seen in a recent official despatch that the length of this right-bank line was greater by 34 miles than that on the left-bank, whilst the Government of India admitted that, owing to uncertainty as to the cost of the bridges, the total cost of either line might be considered the same. Setting aside, therefore, the disadvantage of increasing the length of journey by 34 miles from the seaboard—had the Government of India calculated the cost of working and maintaining that extra 34 miles of line? He found that, taking 2 trains each way daily, which was the basis of the government calculation for rolling-stock, the cost of working and maintaining these 34 miles of line—capitalised—would come to £223,360, or £103,360 more than the estimate of the Government officers for a second bridge over the Indus between Rohree and Sukkur; so that by adopting the left-bank line, with a second bridge at Sukkur, the Government of India would save 34 miles of permanent detour, £103,000 in cash, and would have their line on the safe side of the Indus, as demanded by the Commander-in-Chief. He would now beg to direct the attention of the Meeting to the relative cost of constructing the Indus Valley railway on a standard, or 5 ft. 6 in. gauge, and, on a mètre, or 3 ft. $3\frac{3}{8}$ in. gauge; and in doing so, as the Author had quoted chiefly from Mr. Fowler, so Mr. Lee Smith proposed to do the same, in every case where Mr. Fowler's figures were available. He would have given his own figures, which were worked out in greater detail, and would, he believed, be much nearer the truth, but he preferred quoting from those high authorities whose opinions ought to command more weight.

In explanation of the table which he had prepared, of the "Estimated cost of constructing the Indus Valley railway" (page 96), he stated that he was well aware that Mr. Fowler's price for rails was much under the present market-rate, but so also, as it happened, was the price quoted on the mètre gauge side of the account, and the comparison, therefore, was perfectly fair.

ESTIMATED COST OF CONSTRUCTING THE INDUS VALLEY RAILWAY.

With a standard, or 5 ft. 6 in. gauge.		With a mètre, or 3 ft. 3⅜ in. gauge.		
	£			£
Mr. Fowler's estimate	3,056,404	Mr. Molesworth's Report, Consulting Engineer to the Government of India . . .	271 miles × £6,300 =	1,707,300
Addition on account of 13 miles extra length of line, at the same rate	85,394	Ditto ditto . . .	222 miles × £6,000 =	1,332,000
Extra cost of the line up to the Bolan Pass if made on the standard gauge, claimed by Mr. Thornton	180,000	Consulting Engineer to Bombay Government, estimate of Indus Bridge at Sukkur		120,000
		Additions:—		
		Messrs. Fowler and Thornton's estimate of altering the Scinde and Punjâb railways . .	£327,177	
		Additional cost of altering the Scinde line, which is 165 miles long with its sidings, instead of 105 miles as estimated by Mr. Fowler . .	£22,500	
		Messrs. Strachey, Dickens, and Rendel's estimate for altering Lahore station	£17,500	
Total of standard gauge . .	3,321,798	Transport, sale, and loss upon rolling-stock of Scinde railway, say	£19,000	
Balance in favour of ditto . .	223,679			386,177
	£3,545,477	Total of mètre gauge . .		£3,545,477

The estimate of Mr. Fowler for a line upon the standard gauge, between Kotree and Mooltan, was £3,056,404. To this he should make an addition of £85,394, the second item, on account of 13 miles extra length of line, Mr. Fowler having taken the line as 480 miles instead of 493 miles in length; and the third item was the £180,000 claimed by the Author as a saving to be effected by constructing the line between Sukkur and the Bolan Pass upon the mètre gauge, and which—although, upon such a piece of line, it seemed quite three times as much as ought fairly to be claimed—Mr. Leo Smith meant to allow rather than dispute. These three items would give the total cost of the standard gauge as £3,321,798.

He would now explain the items in reference to the mètre gauge on the other side of the diagram, namely:—

Miles.		£
271 × 6,300	=	1,707,300
222 × 6,000	=	1,332,000
Indus bridge at Sukkur		120,000

The Meeting would probably desire to know whence he got those figures. They were taken from the report by the Consulting-Engineer for State Railways to the Government of India, who stated [page 10, par. 17] that the cost of the line would be as he had quoted; namely, between Mooltan and Kotree, about £6,300 per mile; and between Rohree and Kotree about £6,000 per mile. The estimate of the Indus bridge at Sukkur, was that made by the Consulting-Engineer to the Bombay Government; and although he considered it greatly under the mark, he preferred to take those figures.

To these three items certain additions were required to be made. The first, of £327,177, was Mr. Fowler's estimate of the alterations upon the Scinde and Punjâb railways, and which sum was admitted by the Author. The second item, of £22,500, was on account of an error made in the length of the sidings of the Scinde railway, which, with its sidings, was 165 miles, instead of 105 miles in length, as quoted by Mr. Fowler, and which would, therefore, require alteration to the further extent of the item quoted. The third item was for the alteration of the main changing-station at Lahore, which Mr. Bidder had put down at £50,000. Mr. Leo Smith had taken it at the more modest figure of £17,500, which was the sum allowed on this account by Messrs. Dickens, Strachey, and Rendel; and the last item was on account of the carriage and sale of the Scinde railway stock, the depreciation of which, in Mr. Harrison's opinion, should be taken at 50 per cent.; but which he, to be on the safe side, had taken at the moderate figure of 10 per cent. These together amounted to £386,177, which had to be added,

to arrive at the total of the mètre gauge, and which left a grand result in favour of the standard gauge of £223,679.

He had quoted the principal figures upon this side of the account from the report of the Consulting-Engineer to Government as being the highest authority on the subject, though he did not suppose that the estimates of £6,300 a mile, or £6,000 a mile, professed to be perfectly exact. It was in the power of the authorities of the India Office to invalidate his calculations by informing them that they had received later and more precise information; but if challenged upon this point, he would at once produce incontrovertible proof that the figures were quite accurate enough for his purpose, which was, to show that the economy put forth as the plea for breaking the gauge of the Indus Valley line had no foundation in fact; that, on the contrary, there was a decided balance in favour of the standard gauge; and he hoped the Meeting would now appreciate, and possibly would even join in, the Commander-in-Chief's protest, recorded thus in his Lordship's own words:—"I dissent from the 24th and 27th paragraphs. I am unable to consider the construction of the Indus Valley line on a broad gauge 'a financial impossibility' under the present circumstances of India."

Here they ought to stop. There was no need to say a word about the Peshawur line in the face of the admission made by the Governor-General and his council in these words:—"We have no hesitation in saying that were it a question of the section between Lahore and Peshawur alone, we should at once dismiss from consideration all idea of anything but a standard-gauge line." It was futile to argue, that because the Government had now elected to follow the line of the Grand Trunk road there was the slightest necessity for doing so. The original order for the examination of that line ran thus:—"Between the two termini, Lahore and Peshawur, there is but one intermediate compulsory point through which the line must pass, and that is Rawal Pindi."

Bearing this in view, Mr. Lee Smith decided to take the shortest route admissible by the natural obstacles of the country, which would secure the carriage of the salt, the only existing important traffic of the district. In doing so, he had the high approval of Lord Lawrence, who advised that the line should go by the salt mines.[1] In short, the line which he recommended was approved

[1] "I incline to think, with Colonel Strachey, that the most convenient line for a railway would be from Lahore to Goojerat and thence by a curve to Pind Dadun Khan."—*Minute by the Right Hon. the Governor-General, dated 27th March, 1865.*

by the Punjâb Government and by all the authorities, but the whole project was abandoned for the time on account of the expense. How the Grand Trunk road line came afterwards, and through a complete mistake, to be adopted was a long story. He told Lord Mayo that the utmost he would save by cutting up his second line of communication, the Trunk Road, would be £200 per mile, and his Lordship said, half laughingly, "And a very important saving too!"

But to conclude. The new orders for the State railways, with curves of 330 ft. radius, and gradients of 1 in 40, instead of 1 in 70, as he had previously been working on, at once removed all objections on the score of heavy works, and made the line *viâ* the salt mines feasible, and on seeing this, he wrote without delay, as a Government servant, and begged that the matter might be reconsidered. This was on the 16th of February, 1871, exactly two years ago. He stated that the line "would be straight, almost as the crow flies, and could be made as cheaply as the Great Trunk road one." He tried all his powers of persuasion, and even after he left the service, he still continued to urge the advantages of the salt line upon the notice of the authorities. He worried every one whose influence he thought might be brought to bear on the subject to listen to him. But all was of no avail. He begged one of the members of the Finance Committee to have him summoned, who promised, that if the other members thought it worth while, he would endeavour to do so; but Mr. Lee Smith had heard nothing further on the subject.

He had made similar calculations with respect to constructing the Peshawur railway on the standard gauge, and the results were shown in the table (p. 100). He found that by following the direct line there would be a balance in favour of that gauge of £253,828. Believing that where the gauge of these two lines—"of as great strategical importance as any yet to be made in India"—was hovering in the balance, the subject was worthy of the serious attention of Government, he used his best powers of persuasion, not in writing only, but in a personal interview with the Under-Secretary of State, to induce him to refer the matter to a committee, alleging that half an hour would suffice to test the truth or the fallacy of his assertions, but without avail. In conclusion, he begged leave to record his firm conviction that the break of gauge would certainly result in a clear loss of not less than £300,000 or £400,000.

Mr. J. Allport said that, as his experience in the working of railways had extended over a great many years, and for a consi-

ESTIMATED COST OF CONSTRUCTING THE PESHAWUR RAILWAY.

With a standard, or 5 ft. 6 in. gauge.	£.	With a mètre, or 3 ft. 3⅜ in. gauge.		£.
Offer made by influential contractors to make the whole line (and salt branch) from Lahore to Peshawur	3,464,400	Mr. Molesworth's Report, Consulting Engineer to the Government of India . . . 340 miles × £6,400 =		2,176,000
Government supervision at, say, 2½ per cent. . .	86,610	Ditto ditto for the three great bridges .		1,125,000
Add for rise in price of iron since the offer was made	76,380	Ditto ditto for a second bridge across the Jhelum, taken at the same rate		250,000
		Additions :—		
		Loss upon 100 miles of heavy permanent way sent out for this line, being the difference between 60-lbs. rails and 40-lbs. rails and fittings . .	£63,558	
		Loss on carriage of salt over 30 miles of line needlessly. Estimated out-turn = 100,000 tons, at 1*d.* per ton per mile, = £12,500 per annum. Transfer from narrow-gauge trucks to broad-gauge trucks at Lahore of, say, 50,000 tons, at 4*d.* = £833 6*s.* 8*d.* per annum; together, £13,333 6*s.* 8*d.* capitalized = . . .	£266,660	
Total of standard gauge . .	3,627,390			
Balance in favour of ditto . .	253,828			330,218
	£3,881,218	Total of mètre gauge . .		£3,881,218

derable portion of the time in connection with 'break of gauge,' he might venture, without alluding especially to Indian railways, to state what his views were upon that point, and also in reference to the relative advantages of the broad gauge and of the narrow gauge in Great Britain.

With regard to break of gauge, his experience had been considerable for some years past, inasmuch as a portion of the Midland railway had been constructed on the broad gauge and another portion on the narrow gauge. The break took place at Gloucester, and such were the evils it entailed, that many years ago the company determined, at great cost, to make eight miles of narrow-gauge line, and to convert the old line into a mixed gauge. The Act authorising the conversion provided, however, that the broad gauge should not be taken up; and though that broad gauge, by Act of Parliament, was obliged to be kept down, because it was in connection with the broad gauge from Bristol and also from Gloucester, yet from the time the narrow gauge was opened, not a single engine passed over that broad gauge to and from Gloucester, and the greater part of the rails had been kept down almost to the present day —certainly till within the last twelve months. Now the transfer of the traffic at Gloucester was so great an evil, that the South Wales railway and the Midland railway absolutely made arrangements for allowing eight miles of mileage to compensate for that break of gauge; whilst in another case, the allowance was now twenty miles. He had frequently had occasion to mention it before committees of Parliament; he thought in all cases the delay of the break of gauge was never less than one day, and very frequently it was two days.

The question of salt had been alluded to, and up to the present day a large amount of salt was transhipped from the narrow gauge to the broad gauge at Bristol, and that was done, not only at considerable expense, but at great loss.

In reply to Mr. Thornton's question—through the President— of what quantity of salt was brought? Mr. Allport said, that not intending to take part in the discussion, he had not brought any figures with him; but there were many thousand tons a year, but whether it was 10,000 or 100,000 the question was the same. There could be no question that upon low-priced articles like salt and coal, the break of gauge was destructive to the traffic; and he ventured to ask practical men whether it was possible, looking at the mineral traffic carried on many British lines—taking the Midland railway as an example, carrying between eight and nine millions of tons of coal alone—with all the appli-

ances that could be arranged, to tranship that quantity of traffic; large or small, the question of cost per ton must be the same, providing there was sufficient traffic to occupy a certain number of men, wagons, and trucks. And it must be a poor traffic indeed that would make the cost, because of its smallness, larger per ton than if they had a large traffic to deal with.

With regard to the goods traffic generally, a narrow-gauge truck would take from 5 tons to 6 tons, and a broad-gauge truck would carry 10 tons. Supposing there were not 10 tons to put into a broad-gauge truck, the same quantity had to be taken in a broad-gauge truck that could have been loaded into a narrow-gauge truck, and that, he need not remark, was a great loss; such was the practical experience of men who had had this transhipment under their observation. The result was, they transferred from the narrow gauge to the broad gauge the same goods, and the extra weight of the broad-gauge trucks must be so much loss as dead weight.

A few years ago experiments were made at the instance of the War Office, in loading a battery of six guns, with horses and equipments, partly at the King's Cross station and partly at the Euston station, to travel a certain distance and then to unload. Any one who witnessed that operation must be convinced that to tranship an army of even only 20,000 men or 30,000 men, with horses and equipments, would be so prejudicial and would cause such a vast loss of time, that it would be better, in his judgment, for the army to march by the road rather than to undergo that transhipment. He did not believe it could be done. The difficulty of getting horses out of one truck and putting them into another was so great, that he did not think any officer would undertake the task; and as to the guns, the difficulty of getting them first into the trucks and then shifted to a different gauge would be so great, that the time lost and the expense of it would justify a commanding officer in deciding to take his guns by road rather than by railway. He knew from experience the difficulty of getting a large number of horses into trucks of the 4 ft. 8½ in. gauge; how they were to be carried on the mètre gauge he was at a loss to understand; and he thought that remark would apply to a very large amount of what was termed the 'impedimenta' of an army. Then, again, with regard to the men—they could not be expected to carry all their accoutrements with them in the carriages. In the conveyance of troops the muskets were generally put into separate vans, and it was an easy thing if they had 50 trucks of one gauge to put their contents into 50 other trucks of the same

size and gauge, much easier than to put the loads of 50 broad-gauge trucks into 70 narrow-gauge trucks or 80 narrow-gauge trucks. The difficulty of the men finding what belonged to them would increase the difficulty of moving an army under such circumstances. This last autumn he was requested, being in Canada, to give his opinion with respect to the Grand Trunk railway in that country. One of the first difficulties that struck him was the break of gauge on that railway. After discussing the question with the President of the company, the Engineer, and the Manager, it was decided unanimously to recommend the shareholders to expend a very large sum of money in altering the gauge of that line. He regretted that the poverty of the company compelled them to limit the change of gauge to a certain portion of the line only, as he was convinced it would have been a great benefit to them if they had altered their entire system to the ordinary gauge of that country. He regretted he had no facts and figures with him to bear out what had been said by the last speaker and by Captain Galton. He thought if there was a curse on a railway system in any country it was having different gauges. It was the duty of the government of any country to insist upon a uniform gauge. The adoption of the narrow-gauge for the lines proposed in India might entail the loss of that country to the governing classes; and he would strongly urge upon all who had any influence in deciding this question to insist upon the entire railway system of India being constructed upon one uniform gauge. He did not wish to say the mètre gauge was superior or inferior to the 4 ft. 8½ in. gauge, the 5 ft. gauge, or the 5 ft. 6 in. gauge. He had, however, a strong opinion in favour of the 4 ft. 8½ in. gauge, or, at the most, the 5 ft. gauge; but what he did say was, that in his judgment, for the welfare of the country it was imperative upon the Government to insist upon one uniform gauge.

Captain Tyler, reading from copious notes, said he had felt great hesitation in taking part in this discussion, but it had been represented to him that as he was the first to bring the subject of railways on a narrower gauge than 4 ft. 8½ in. before the Institution,[1] and as he had since taken a somewhat prominent part in experiments and discussions on the subject, it would, or might, be supposed, if he did not now express a contrary opinion, that he was in favour of an universal mètre gauge for the Indian State railways. He could fully appreciate the position of the Indian Government in this matter. They

[1] *Vide* Minutes of Proceedings Inst. C.E., vol. xxiv., p. 359.

had constructed and guaranteed interest on the cost of 5,000 miles of railway, in a country 1,800 miles long by 1,500 miles wide, containing 200,000,000 of inhabitants; they conceived rightly, that, for the due development of the country, it was essential to construct a further network of, say, 10,000 miles of railway: and they believed, rightly also, that it was of great importance to effect as much saving as was consistent with efficiency on this large system. They were naturally disposed to look despondingly at the heavy interest which they are called upon to pay for existing lines, and were as naturally desirous of making future lines pay interest on the outlay to be incurred on them. They, therefore, took up warmly the question of narrow-gauge construction, and they were desirous of utilizing it to the uttermost.

Now, as a warm advocate of a narrow gauge in its proper place, he had been quite unable—and he was glad of the opportunity of saying so publicly—to follow the later advocates of narrow gauge into all their extremes, and he also dissented from those uncompromising opponents of narrow-gauge lines who would oppose them in all cases and under all circumstances. There were gentlemen who would tell them that the heaviest traffic might be carried more cheaply on a 3 ft. gauge than on a 4 ft. 8½ in. gauge, or a 5 ft. 6 in. gauge, on the one hand; and there were others who would tell them that the narrow gauge was not capable of being worked with sharper curves, and was hardly less expensive in a difficult country, on the other hand. He did not care to discuss the matter with gentlemen holding either of these opinions. But he did believe that a 3 ft. gauge or a 3 ft. 6 in. gauge was suited to some circumstances, and that a 4 ft. 8½ in. gauge or a 5 ft. 6 in. gauge was suited to some other circumstances; and the question at issue was, to what circumstances were they respectively suited?

The elements to be considered were:—

1. First cost in construction,—comparatively.
2. Cost and efficiency of working and maintenance,—comparatively.
3. Nature and quantity of traffic.
4. Gauge of existing railways, and number and position of points at which there would be break of gauge.
5. Strategic requirements.

These points required to be considered separately and carefully, with reference to each particular line to be constructed; and they led to other important considerations, such as speed and general efficiency.

In the present instance, the Author, taking the best materials in

his possession, endeavoured to arrive at a comparison of cost which was evidently anything but reliable, when applied to 10,000 miles of railway over a country of vast extent, presenting great varieties of character, climate, and traffic; and he rather summarily disposed of the question when he said that there must be either narrow-gauge railways or no railways at all. Perhaps the Author would be nearer the truth if he were to say that India must have railways, of whatever gauge; but they ought to be made in the cheapest possible way, consistently with the most economical and efficient working and maintenance.

Various opinions had been expressed as to the saving to be effected by the adoption of the mètre, or narrow gauge. This was estimated by Mr. Bruce at £200 per mile, by Mr. Harrison at £400 per mile, by Mr. Thornton at £1,000 per mile; by Mr. Fowler and by Mr. Hawkshaw at different figures between these extremes; by General Strachey at £1,000 per mile to £1,500 per mile, in permanent way alone, and as much more in other items, say £2,000 per mile. Now the extreme difference between £200 per mile and £2,000 per mile, multiplied by 10,000 miles, became no less than £2,000,000 against £20,000,000.

The Institution ought not, and it could not, seriously discuss the question without more accurate information of a reliable character. Mr. Harrison did the best he could, with the information before him, to pull to pieces the estimates of two other eminent Engineers of the greatest experience, and to found his own conclusions upon the ruin which he had effected; but Captain Tyler hardly supposed that Mr. Harrison's conclusions would be quite satisfactory to himself, and he was sure that Mr. Harrison would prefer, and would be the first to advocate, that in a comparison of cost as between two gauges, the precise line of railway should be indicated, precise information in regard to it should be obtained, and accurate estimates of that particular line should be framed.

Captain Tyler held that the method adopted by Mr. Thornton, of averages between Mr. Fowler's estimate and Mr. Hawkshaw's estimate, produced results which, under different circumstances, and for different lines, were entirely fallacious. Facts and figures were proverbially deceptive, but averages were perhaps still more deceptive. He remembered in one case finding fault with some fish-bolts which were too short, and having it pointed out to him that, as others were too long, the average was sufficient. Similarly, when, on a very recent occasion, he had referred to a train as having been run on certain days at too high a speed, he was met by the reply

that the average running speed of the same train for the month had not been excessive. The absurdity of such averages was obvious, and it was, he contended, almost as improper to take any average between the estimates of £200 per mile and £2,000 per mile above referred to—and to multiply it by 10,000, in order to arrive at the saving of the mètre gauge over the 5 ft. 6 in. gauge, for future Indian railways. Some of the projected lines would show a greater, others a less saving in this respect; and it was only right and proper to take each case, with accurate estimates and information, on its own merits, and then duly to weigh the different conditions of the problem.

Another instance of the fallacy of averages improperly applied had been afforded by General Strachey, who had cited the average traffic carried on a working railway, and then contended that—as such average traffic could be carried on a railway on the mètre gauge—railways on the mètre gauge would be capable of doing all that could be required of them. The traffic on the East Indian railway was, he apprehended, much greater on some parts than on other parts of the line, and at certain times and seasons, than at other times; and the same would be the case on the lines yet to be constructed. And any one, who knew anything of railway working, was well aware that the inconvenience of a crowded traffic, which was severely felt at certain times and seasons, and on certain lines, would be very easily dealt with, if it could be averaged and distributed at the pleasure of the traffic managers. To take a familiar instance, the carriages and platforms of the Metropolitan railway were sometimes overcrowded and sometimes empty; or take the case of Easter traffic or Christmas traffic in this country, or the Scotch traffic at certain seasons, and the same was the case. The question really was, whether the mètre gauge would be sufficient for the maximum traffic that could be brought upon the lines constructed on that gauge, at all times and all seasons, rather than whether it was adapted to the average traffic of any existing line. What that traffic was, over all or any of the various lines proposed, they had no present means of knowing, and it was therefore impossible for them profitably to discuss further this part of the subject.

Then, again, the comparative cost and efficiency of working and of maintenance, as between the two gauges, depended upon the character and quantity of the traffic; and there was one point that he had not heard referred to in the course of this discussion—that of speed. It was obvious that, on long lengths of line, it might be a

great object to run, at times, if not with daily trains, at a high rate of speed, in order to save time on long journeys; and the mètre gauge could not be considered to be well adapted for such high rates of speed. On lines, therefore, on which high rates of speed might be required, it was one argument against the mètre gauge that it was not so well adapted to high speed as the 5 ft. 6 in. gauge, and especially if stability were to some extent sacrificed in the rolling-stock.

The disadvantages, which he had seen in practice for so many years, of the break of gauge—which had at length been happily put an end to in South Wales—had been already sufficiently referred to; and Mr. Allport had referred to the change of gauge that had been lately effected on a line with which Captain Tyler had been many years connected in Canada. The circumstances of the Grand Trunk railway were peculiar. A break of gauge had there actually been effected during the past year between one part of the line and another; and that which was ironically proposed by a previous speaker had thus been carried out in practice. The gauge of that railway had been narrowed for 180 miles between Sarnia and Fort Erie, on the opposite side of the Niagara river, to Buffalo, from 5 ft. 6 in. to 4 ft. 8½ in.; and the lesser evil of a break of gauge had been incurred—it was hoped temporarily—at Stratford, in order to avoid the greater evil of the break of gauge at two important points on the line, which were in connection with the great American lines of railway. The Author, however, spoke of a break of gauge as not being of great importance, for he said:—"If, in some unforeseen emergency, a regiment ever did arrive by rail at Lahore, requiring to be sent forward immediately, the only time lost would be the half hour or so spent by the men in walking from the broad-gauge train to a narrow-gauge train, already laden, in anticipation of their arrival, with whatever guns, ammunition, &c., were needed for their full equipment. This occasional half hour or so would be the only delay (if any) which ever could be caused by break of gauge."[1]

All those who had studied the question of transporting bodies of troops by railway would well understand what he meant when he said that the difficulty was not to run trains along the lines, but to collect the necessary rolling-stock at one end, to arrange for the arrival of the troops, horses, guns, munitions, provisions, stores, &c., to get the soldiers into the carriages, to embark the 'matériel,' &c., to send them off train after train, and then to disembark them at

---

[1] *Vide* ante, p. 15.

the other end; and they would further understand the difficulties, delays, and confusion which had to be encountered, in remembering that a break of gauge necessitated all those operations being gone through twice over. In this case of the Indus Valley line, there were 1,000 miles between Kurrachee and Peshawur, and he need not dwell upon the importance of being able, in a case of emergency, to transport troops rapidly over portions or the whole of that route. They had been led to believe that one great advantage of having railways in India would be, that they might without fatigue to the troops by long marches, take them through the country, and whilst employing smaller forces, be prepared to concentrate within a short period the number of men required at any point. He maintained that, not only by break of gauge in certain localities, but also by using the mètre gauge for certain through routes and in certain localities, they would do away with many of the advantages which had thus been anticipated from having railways in India.

In conclusion, he said, the question before them was a very serious one—serious to the Indian Government—serious to the maintenance of the British rule in India. It was one which ought only to be decided after the most careful computation, the most careful inquiry, the most detailed examination. It had its financial, its political, and its strategic, as well as its engineering aspects. It was capable of closer discussion than it had received, as far as was apparent, from all these points of view. Those who had decided it ought, he thought, to be able to tell them why the mètre gauge was the best to be adopted, and why it should be universal, and precisely where those 10,000 miles were, which had been included, as they were told, in the 'programme'—how many breaks of gauge they would ultimately entail, with existing lines—what amount of traffic and what description of traffic might hereafter be expected to be dealt with, at those points of breaks of gauge. When that information had been obtained or afforded, other questions would also come forward for discussion, namely, 1, whether, if and when 10,000 miles had been constructed on the mètre gauge, it would not be found necessary to convert the 5,000 miles, now existing, on the 5 ft. 6 in. gauge, also to the mètre gauge; and 2, whether the mètre gauge would be a satisfactory gauge to adopt universally throughout such a country. He ventured to suggest that it would be very wise on the part of the Indian Government to reconsider the whole subject, and to do so—not with a foregone conclusion, that what was good for one portion or various portions of the country was good for the whole country—not with reference

to an average multiplied by 10,000 to make up an assumed saving in first cost—but after deliberate consideration of the various elements of the case, such as he had indicated, and their detailed application to the different districts in which railways were to be constructed.

Mr. C. E. SPOONER, reading from a manuscript, said, that it would appear there were two things that must be the cause of Indian railways not having resulted successfully in a commercial point of view: either the lines constructed had cost too much, or there was not sufficient traffic to pay fair dividends upon capital expenditure. The Paper appeared to point out that the want of success was really due to both those causes. From diagrams which he had made of the comparative difference of the works of a single, and of a double line of railway of the 5 ft. 6 in. gauge and of the mètre gauge, with the same radii and curves for one as for the other—not, in fact, showing the full advantage derivable from the narrow gauge—he had arrived at the conclusion that the proportionate percentage in favour of the mètre gauge, over that of the 5 ft. 6 in. gauge, was 32 per cent. for a single line, and 31 per cent. for a double line of railway.

The cost of the railways, already constructed in India, on the 5 ft. 6 in. gauge—less freight and insurance, telegraphs, stores, rolling-stock, engines, and establishments—amounted to about £11,000 per mile.[1] Taking this cost as a datum, upon the 5,000 miles of railway already made, the 32 per cent. gain in construction, if made on the mètre gauge, or £3,520 less cost per mile, would show a total

[1] AVERAGE COST per MILE of EARTHWORKS, BRIDGES, PERMANENT WAY, and STATIONS on the INDIAN RAILWAYS, according to Mr. DANVERS' Report:—

	Length reduced to Single Miles.	Cost of Works, &c.
		£
East Indian (main line) and Jubbulpore	1,559	16,355,000
Great Indian Peninsula	1,128	14,672,059
Madras (South-West line)	492	6,117,250
Ditto (North-west line)	185	
Bombay and Baroda	325	4,805,000
Scinde	114	967,129
Punjâb	246	1,025,983
Delhi	174	3,204,535
Eastern Bengal	113	1,960,729
	4,336	49,107,685
Average cost per mile		£11,325

C. E. S.

saving of £17,600,000 to the State. If the 10,000 miles contemplated, were made on the mètre gauge, instead of on the 5 ft. 6 in. gauge, the saving would be £35,200,000; and that would be the minimum difference of cost, without mentioning the advantage gained in earthworks, &c.—by the use of sharper curves through undulating lands and a hilly country—and in maintenance and renewals of permanent way, and by the less wear and tear of the rolling-stock. That total saving of £17,600,000 would be equal to £880,000 annual saving, out of the £1,600,000 that the Indian rate-payer had now to pay. For the 10,000 miles of railway proposed, the annual saving would be £1,760,000, without calculating any gain through greater durability of permanent way or the economy of working the mètre gauge, over that of the 5 ft. 6 in. gauge. It must be admitted by all, that the Indian railways were a commercial failure. The object sought was to obviate a similar failure as regarded the construction of future lines. The making of light railways upon the standard gauge appeared to him to be inconsistent and wrong in principle. The cost of earthworks, bridges, tunnels, &c., to formation-level would be alike in both cases, nor would the supposed economy in lighter engines and rolling-stock be found to succeed.

The Author, after his analysis of Mr. Fowler's estimate and of Mr. Hawkshaw's estimate, assumes the difference in cost between the mètre gauge and the 5 ft. 6 in. gauge in land, earthworks, bridges, sleepers, and ballast would be £1,000 per mile for the contemplated lines in the Punjâb. This amount was less by £2,520 per mile than the minimum difference, he was able to arrive at, according to the above estimates. For economy of construction, and to meet the necessity of opening out the Punjâb, Indus Valley, and Rajpootana districts, it would appear advisable that the lines should be constructed of the mètre gauge throughout; also, that the existing 5 ft. 6 in.-gauge lines between Lahore and Mooltan, and between Kotree and Kurrachee, be converted to the mètre gauge, and the proposed line between Lahore and Peshawur and Mooltan and Kotree be constructed on the same gauge, making a through trunk line, on that gauge, of 1,092 miles. Then there would be the collateral lines from Sukkur to Dadur, and from Sukkur to Rajpootana. The rolling-stock could be drafted on to the 5 ft. 6 in.-gauge lines from off the Lahore and Mooltan railway, and the line from Kurrachee to Kotree. Mr. Fowler's estimate for laying down a third rail between Lahore and Mooltan, and for relaying the line between Kotree and Kurrachee on the mètre [illegible] a length of 319 miles, was £327,177, or £1,025 per mile;

so that, on the same data, if two rails were laid down, it would cost £2,050 per mile, while his estimate of £680,000 for the 773 miles gave a saving of only £879 per mile.

It would appear that if a plan was adopted to supply the mètre gauge in the Punjâb and Rajpootana country with a transhipment depôt station at Lahore, a much larger saving could be effected to the state. Supposing that the 773 miles from Peshawur to Lahore, and from Mooltan to Kotree, were constructed on the mètre gauge, and that the 5 ft. 6 in.-gauge lines from Lahore to Mooltan, and from Kotree to Kurrachee were altered to the mètre gauge, the saving would be £2,548,693.

Supposing, on the other hand, that the 773 miles were constructed upon the light system, and the standard gauge between Lahore and Mooltan, and between Kotree and Kurrachee remain untouched, the difference in favour of the mètre gauge would be £1,737,043. He was laying a 2 ft.-gauge line through rather a hilly country, and he did not hesitate to say, that with proportionate curves to those of the 5 ft. 6 in. gauge, the earthworks would cost nearly four times the money.

In regard to the transhipment of traffic, the difficulties were more imaginary than real. With the transhipment junction of the Festiniog and Cambrian railways, where a traffic at the rate of 25,000 tons annually was conducted, but which was laid out for more than double that traffic, the difference in cost over the ordinary junction was £2,740. Of coals, lime, or other heavy material, 2 men could tranship 100 tons in 1 day of 10 hours, or at a cost in wages to the company of 1*d*. per ton from one tipping apparatus, but the charge by the company was 4*d*. per ton, to cover cost of works, land, engines, &c. Timber and goods were transhipped to the extent of 50 tons in 10 hours by 2 men with a crane, or, in wages, about 2*d*. per ton. Of slates, which had to be carefully moved by hand and packed, 4 men could tranship 60 tons in 10 hours; from 3*d*. per ton to 6*d*. per ton was paid when the work was let on contract, on account of the irregularity of the work. The time occupied by passengers in moving from one platform to the other was about 5 minutes. Light goods, from the transhipment warehouse, or from one truck into the other, were changed with rapidity. No compensation, up to the present time, had been paid by the company for damage on transhipment of minerals or goods. A similar transhipment junction at Lahore, upon a more extended scale, might be made, so as to accommodate any possible amount or description of traffic, and it could be furnished with cranes, tipping apparatus, goods-sheds, &c. Had the contemplated lines been but a

few miles long, it would have been easy to understand the objections made as to transhipment; but when a whole country of so many thousand square miles, and the great length of the proposed lines, with their full complement of rolling-stock and engines, was considered, the objections could not for a moment hold good, as it practically could only occasion a few hours' delay in the transit of minerals and goods, and of military stores; and passengers would only be delayed a few minutes. The small cost of transhipment and loss of time in transit was too insignificant to be considered, when it was divided over so large a mileage. There would be no change, from one gauge to the other, of stores and passengers for the whole of the North-Western provinces, excepting at Lahore, and probably a large military depôt would be established at that point by the Government.

Lord LAWRENCE said he would not attempt to enter into the vexed question of the relative merits of the broad, and of the narrow gauges. It was a matter of professional opinion, rather than that of a man trained as he had been; but this he could say, that—bearing in mind that hitherto there had been in India a broad gauge—he thought, as a matter of convenience, they ought to continue the broad gauge, unless there were strong reasons to the contrary. Nevertheless, he was bound to say, he thought there were strong reasons for further consideration. He believed, as a matter of fact, they ought to consider the question of cost rather than the question of convenience. A gentleman had stated to the Meeting that he could make a railway, on the Madras coast, on the broad gauge very nearly as cheaply as he could make one on the narrow gauge. There might be peculiar circumstances which would enable him to do something of the kind; but, as far as Lord Lawrence's experience went—and without aspiring to professional knowledge on the subject, he might say he had some experience of the matter, and had studied it—he believed it was quite out of the question that they could make a railway on the broad gauge, with anything like the cheapness they could make one on the narrow gauge. He preferred judging of the future by the experience of the past. Something like 5,000 miles of railway in India had been constructed on the broad gauge, and these 5000 miles had, in round numbers, cost £90,000,000 sterling; therefore about £18,000 per mile had been spent upon these 5000 miles. He had never heard any engineers say that they could make a railway on the broad-gauge principle under £10,000 per mile; and he believed, as regarded the Mooltan line, the estimates were something like £12,000 per mile. On the other hand, he understood that the portion

of that railway which was to be made on the narrow gauge could be constructed for £7,000 per mile. That was called the missing link between Mooltan and Kotree, and was something like 450 miles in length. In the case of the broad gauge then, it might be assumed that the estimate was £12,000 per mile, and in the case of the narrow gauge £7,000 per mile. On the 450 miles the extra cost of the broad gauge would be something like £2,500,000 sterling. Then taking the upper part of the line, from Lahore to Peshawur: the difference in cost was £1,500,000; so that on the whole line from Peshawur to Kotree between the broad gauge and the narrow gauge there would be a difference of something like £4,000,000 sterling.

It was scarcely necessary to say that India was a country with an enormous area; it was, moreover, a poor country. Its great wealth was its agricultural produce. There was not much doing in the way of mining operations. There was not much in the way of manufactured goods to carry; what would be carried on that railway, in particular, would principally be agricultural produce. The lines they had hitherto made in India were the main lines; for the most part they were through the richest and most fertile and best populated parts of the country. Now it was notorious that those lines, having regard to the capital expended upon them, did not pay. Some of them would in course of time, no doubt, do so; but a large portion would perhaps never pay at all. Now, bearing this in mind, it followed that the tracts of country through which the new lines would go were, by comparison, poor; and if the main lines, at their high cost, did not pay, the branch lines in the poorer parts of the country would have a still less chance of paying. The only chance of their making an adequate return would be by constructing them in the cheapest and most economical way, consistent with efficiency.

Now, if he could show that the line from Peshawur, down to Lahore, and from Lahore down to Kurrachee and the sea, would not suffer, as a railway, from a break of gauge, he thought it would follow that a break of gauge might be permitted in other parts of the country. The line he had adverted to was notoriously made for a considerable extent for military purposes. From Lahore to Kotree the country was badly cultivated; it was in many places a wilderness. The population was sparse, large tracts were desert. The line of railway from Lahore to Kotree had to compete with the River Indus, which, he need hardly say, in its downward course was quite sufficient for the transit of agricultural produce. Now it

was quite hopeless to expect that line to pay a dividend for many years. If it paid as much as its working expenses, for the next eight or ten years, it was as much as they could reasonably expect. The only traffic of commercial importance, going up the river, would be in piece-goods, with regard to which break of gauge would not be very important; but, bearing in mind that it was mainly a military line—and, but for military considerations, it would not be constructed—he maintained that a break of gauge was of no real importance. They could not, in India more especially, nor, indeed, he submitted, in any country, carry considerable bodies of troops through long distances without rest and refreshment. On the other hand, there was no objection to carrying stores and supplies for an army through hundreds of miles continuously. But if their military arrangements were worth anything, they were so arranged as to bear the press of a great demand for a certain time. A matter of a day or two was of no importance as to stores and supplies, which would be accumulated in suitable positions, in depôts in the vicinity of an army on the frontier; but with respect to troops, they must have places for rest and refreshment along the line of a railway; and they could make the resting places where the break of gauge occurred. Where would be the breaks of gauge? Kotree would be one, Mooltan would be another, Lahore would be another. Those were the places where the troops would stop. Moreover, if an emergency arose, the troops would be sent on from place to place, and one detachment would be gradually following up another; so that, in point of fact, whether they regarded the troops, or the stores, or the supplies, there could be no sensible disadvantage in break of gauge at those points he had mentioned. He did not say that circumstances might not occur in which they might wish to send troops more or less quickly to the frontier; but he could scarcely conceive a state of things where really and truly the moderate rate of 100 miles or 150 miles a day in the movement of troops could not do all that the circumstances required. They did not make railways for what might happen once in twenty years, or thirty years, or in the life of a man; but they made them to meet the ordinary wants of the country. He was convinced that—notwithstanding certain disadvantages and inconveniences, which he admitted to be attendant upon a break of gauge—the railways on the narrow gauge would be quite sufficient for all the real requirements of the frontier; and he thought that to do more than that would be really and truly a waste of money.

Now, he was aware, that what he had said would not be very

acceptable to some of his audience. He believed most of them were Engineers, and, without intending to say a word of disparagement to the profession, he thought it was only natural that Engineers should wish to have the best, and most complete, and most effective railways that could be made; and that perhaps, in doing so, they were in some degree—he would not say regardless—but that they did not give sufficient consideration to the question of expense. He thought the Engineer, on such a question as this, should certainly be heard. Much which he had to say was worth hearing, and what he did say should be borne in mind. Regarding this question of a break of gauge in India, it was a question as much for the financier, the administrator, and the statesman, as it was for the Engineer.

Now, the sum and substance of what Lord Lawrence had said was this—except as regarded the break of gauge, he thought the narrow gauge the best. Let them accept the narrow gauge for the future. If they did that, they might have railways in India which would do an enormous amount of good. They would be able to pay for those railways, and in a moderate time such railways probably would pay; otherwise he, for one, said, have no more railways. If they were to get into debt, and to heap up debt after debt, he thought they would get into great difficulties. He thought it was a wise course to do what he had suggested. At any rate, what he had said he believed; and his feeling was so strong, that he felt bound to give expression to it.

Mr. JULAND DANVERS said, that looking at the interest which appeared to have been excited by the discussion, it seemed a little surprising, that before this time no Member of the Institution had brought forward a subject which was regarded as of such great and general importance. Perhaps if the question had been raised at the Institution two or three years ago, it would have been met with less prejudice, and with a little less feeling. Those who had come to teach might have felt they would have had more hope of producing an impression, and those who came to learn might have felt that they were more open to receive instruction; but be that as it might, the Institution must feel indebted to the Author for having boldly come forward and confronted the engineering world with his thesis. The Author had divided the subject into two parts, the first having reference to the general introduction of light railways in India, and the second to the application of that system to a particular district. Mr. Danvers proposed, in the few observations he should venture to submit, to confine himself entirely to the question of the introduction of light railways in

India, feeling that the application of the system was a matter which must of necessity be left to the responsible government of that country. He would ask them for one moment to look at a map of India, and to consider the immense area of the Indian Empire, and also its great resources, and further to trace out the lines of railway which now existed there; and he thought everybody who had any knowledge of the country would at once admit that it was at present but ill provided with railways. Its great want was internal communication. Its resources were large. Its agricultural products, as Lord Lawrence had stated, were the chief staple of the country; but these could not be brought to market for want of proper means of communication. Cattle draught upon ordinary roads was slow, expensive, and uncertain. Mr. Danvers therefore ventured to hope that this assembly would admit that the introduction of any plan which would rapidly provide for that country a system of communication to be worked by mechanical power, was the correct one to pursue. He did not for one moment mean to contend, upon professional grounds, or with technical weapons, with those engineering giants who had preceded him in the debate. He was ready almost to tremble at the notion of getting into the clutches of that powerful triumvirate who had commenced the discussion, and seemed almost to have governed its subsequent course throughout; but he would ask them to descend from the region of science and philosophy to that of common sense.

He had always been under the impression that size had something to do with expense, and that whether the work were a house, a road, a tank, or an embankment, the cost was always in proportion to the dimensions; but he was met by the observation that this did not apply to railways. In answer to that dictum he would venture to bring forward a few facts which had come under his own experience. One line of railway in the upper provinces of India, the Oudh and Rohilkund, was first laid out for a narrow-gauge line. It was estimated that its cost would be £6,000 per mile. After the scheme had been agreed upon, an alteration took place in the views of the government, and the broad gauge was adopted; the cost of the line, in consequence, became £9,000 per mile instead of £6,000 per mile as originally intended. It might be said that a portion of this expense had been incurred in consequence of heavier rails and heavier materials being employed. He granted it. He allowed £1,000 per mile for that, and yet in this example the saving which would have been effected by using the narrow gauge was something like £2,000 per mile.

Another case occurred in Southern India. The Carnatic railway was laid out and estimated, as for a broad-gauge line; but it was afterwards determined that a narrow gauge should be substituted. The original estimate for the broad gauge was £7,000 per mile; the estimate now accepted was £4,895 a mile, leaving a saving of £1,730 per mile. He admitted that the rails would be rather lighter, and producing in that item a saving of about £600. A line had been constructed in Bengal 27 miles in length, being a branch of the East Indian railway, the cost of which had actually been £3,000 per mile, laid—upon an existing road, he should add —with light rails and suitable for light engines; still it answered its purpose. Mr. Douglas Fox had described a line in Canada which had been constructed for £2,400 per mile. That was just the kind of work wanted in most of the districts of India, and why should they not have it there? But Mr. Danvers could bring forward a case where a line at lower cost even than that, had been constructed in India. Mr. Barnett informed him, that when he contracted to construct a portion of the Madras railway, he, for his own purposes, laid down a short line from the main line to certain quarries and depôts with a view of obtaining materials for his work. The line so laid down on the 3 ft. 6 in. gauge was stated to have cost only £2,200 per mile. This, again, was the description of railway which, while probably rough, as well as light, was suited for many districts in India.

Believing, therefore, as he did, that the extension of the railway system in India was much needed; that in most districts the traffic would be accommodated by light narrow-gauge lines; that there would be considerable saving in the construction and working of such lines as compared with broad-gauge lines; that a greater extent of railway communication might be established, than if the broad gauge were adopted, Mr. Danvers came to the conclusion that, notwithstanding the break of gauge involved, the Government was right in introducing light railways on the narrow gauge into India. He did not wish, for one moment, to dispute the disadvantages, in certain places, of a break of gauge; but he did think that the absence of those disadvantages might be dearly purchased, and he thought it would be dearly purchased if they attempted, in India, to continue to take a broad system of lines into the numerous districts that required railway communication. He thought India was indebted to the Council of the Institution, for having allowed so much time and attention to be devoted to a question of so much interest to that country. Many Members of the Institution had done excellent service in India. He hoped that they would continue

to do so, and that they, and their sons after them, would help to promote the prosperity of that country, by taking part in the extension of the railway system upon the cheapest possible principle.

Mr. VIGNOLES, Past-President, said he would not have pretended to enter into this discussion, which had been so ably sustained, and, in fact, upon every point nearly exhausted, by those who had preceded him; but it so happened—and he supposed the fact was unknown to most of the gentlemen present—that more than thirty years ago, when the mere idea of making railways in India was laughed to scorn, he was engaged by leading gentlemen of the East India Company to investigate the desirability and possibility of making railways in India. On that occasion he wrote an elaborate report, and he would ask permission of the Council to have it printed in the Appendix.[1]

In that report he laid down certain leading principles and arguments, and, on looking at it again after the lapse of so many years, there was scarcely one word of those principles or arguments which he would now retract. One of the chief reasons he had for asking that it might be published in the Minutes of Proceedings was to controvert the observation made that engineers, and the members of the Institution in particular, looked to the glorification of themselves and to the magnificence of their works.

The whole argument of his report was "economy." He therein demonstrated that railways might very well be made in India for £8,000 per mile. This report was filed in the records of the East India House; but when that building was taken down there were some three hundred tons of valuable documents disposed of to the paper-makers, and he thought it possible that this report might have been amongst them.

The report, however, was published in the Bombay newspapers in 1843 and 1844, and was commented upon by the eminent Dr. Buist. Subsequently—when Mr. (now Sir) Macdonald Stephenson had urged the question in India and in London—a London Board of Directors issued a prospectus, inviting subscriptions for an East Indian railway, and Mr. Vignoles was appointed Engineer-in-Chief. This post he resigned in consequence of his having been honoured by Lord Dalhousie with the offer of becoming the leading member of a commission, then about to be established by his Lordship, to study the question of railways for India; and, subsequently, the late Mr. J. M. Rendel, Past-President, became his successor in the private company.

---

[1] *Vide* Appendix II.

Circumstances occurred which broke off the negotiation with Lord Dalhousie, of which he would only say that the failure left no reproach on him, though the opportunity was lost for carrying into practical effect the suggestions made, and the principles laid down in his Report.

It was probable that General Strachey had never heard of this report, nor of the report made by the Irish Railway Commissioners. It was quite evident that neither the Author nor Mr. Danvers, nor any of their predecessors in office, could ever have heard of these documents; for there was not a recommendation with respect to the Irish railways which was not applicable, word for word, to India, and there was not a single suggestion in the report which had not been stultified and ignored by those who had undertaken to manage the railway affairs of India, or had carried out the railway system in that country, whoever they might be. Far from allowing any gentleman to say, uncontradicted, that it was wrong for any one in this room to suggest, that what the Government ought to have done now, was to have taken the advice or to have consulted the opinions of the Institution of Civil Engineers, Mr. Vignoles said, that if the Indian Government had done so thirty years ago they would have far better benefited that country, and would have been in a very different position on the question of railways to what they now were.

One of the leading principles repeatedly laid down by the Irish Railway Commissioners was, that, before railways were carried out, as a system, in a new country, the greatest care should be taken in the first instance that those lines which were profitable should be made to pay for those which were not profitable; whereas, by the way in which the railways in India had been unsystematically carried through, the chief profitable lines presenting openings had been executed, under a guarantee of interest from the Government. Mr. Vignoles ventured to say that the advisers of Government had been unfaithful trustees, and General Strachey, Mr. Thornton, and Mr. Danvers, or whoever the trustees for the time were, had been false to that trust. Their trust was, from the beginning, to have studied the question on a much larger basis than those gentlemen appeared to have done. The representatives of the Government had no right to throw in the teeth of the English engineers that it was necessary to be acquainted with all the details of Indian circumstances to judge of a question like this, since they, as trustees, had shown themselves ignorant or neglectful of these very details. This was a great, a national question, which had not been treated as it ought to have been, for the action of the Indian Government,

under bad advice, had left the remoter parts of India in such a situation that the State could not afford to make railways through them, because they had not previously sufficiently studied the resources of the country.

Mr. Vignoles trusted his declaration would be accepted, that it was not of the slightest interest to himself, personally, how the question before the Institution was resolved by the Government. Until the Paper was read he had almost forgotten, for thirty years, either the subject of railways for India, or the consideration of the break of gauge in any country; and he fancied he must have been asleep during that long period, when he was roused up and informed that Indian railways, instead of having been constructed for £8,000 per mile, had really cost £18,000 per mile, and that it was proposed to obviate this extra cost, for the future, by breaking the uniformity of gauge, now spread over a network of 5,000 miles, and thrusting in a narrow gauge of one mètre! And what was this crotchet of a mètre? Was it to insert the thin end of the wedge, and to make a bold step for introducing the whole metrical system of weights and measures into India, as built up on a 'soi-disant' scientific basis? If the Government advisers thought the mètre was a scientific unit they were quite mistaken. It was a mere arbitrary unit, for it had been demonstrated at least twenty years since that the conclusion arrived at by the French philosophers towards the close of the last century, namely, that the mètre was exactly some few millionths part of the quadrant of the terrestrial globe was erroneous, and thus the scientific basis of the mètre vanished. As an Engineer, Mr. Vignoles asserted that the assumed saving of £1,000 per mile was illusory. He maintained that without breaking the present gauge they could have cheap and light railways in India, a necessity which the Government advisers had found out, at last, after twenty-five years of 'meddle and muddle,' and such railways the Government might have quite as efficient, and quite as cheap, within a few hundred pounds per mile, upon the present gauge, as upon the mètre gauge. Though he had prepared ample notes for the purpose, he would not now enter into details. It had been already much better and more effectually demonstrated by others, than he could have done, how absurd and how detrimental the proposed change of gauge would be, and in how little additional cost the retention of the present gauge would really involve the Government.

The consideration of cost led him to observe that, if the difference between the interest guaranteed by Government to private companies and the actual net returns from the railways did

really fall, as a tax, on the great mass of the population, that was on the agricultural class, certain curious questions arose. Had not railways contributed to increase the land revenue of India to the great extent it had swollen to? Had not the districts pervaded benefited enormously? Would not the construction of roads, converging on to the lines of railway, have increased the traffic? and why had not such roads, as feeders, been made? Whose duty was it to have made them? and so on. He would quote his report before alluded to :—" Without observing further on the policy of the East India Company, it may be remarked, that little or rather nothing has been done by them for India for the true development of its resources; since easy means of internal communication—the very first step necessary to effect this object—have never been attempted until very recently indeed; and were the whole projected system of railways unconditionally undertaken by the company, it would be but a tardy fulfilment of long-deferred obligations which their claim of seignorial dues on the land requires of them. That 'property has its duties as well as its rights,' is equally true in India as in Ireland; and quite irrespective of the political colour which was given to that aphorism."[1] An article in the "Athenæum," written several years previously, said :—" A nation may wisely spend money upon other considerations than those which govern a private capitalist."

He would ask what was the state of the roads of India in 1840? He would answer :—In the four collectorates adjacent to Bombay, over 30,000 square miles, an area larger than Ireland, there was only one mile of metalled road for every 50 square miles; and during the rainy season, that is during a third of the whole year, only one mile of road practicable for carriages to every 300 square miles of territory. It was no better, and often much worse, over every other part of India, where the towns and posts of the interior were so many isolated spots during the rains, and however important it might be, either in a military or commercial sense, it was impossible to pass carriages along the roads such as they were.[2]

And so the roads remained, at the present time—the interest being guaranteed to the private companies, they would not make roads as feeders—and the only way for the government to re-coup their annual loss of one and a half million must be to make those feeders themselves.

---

[1] *Vide* Appendix II., § 96.
[2] *Vide* Ibid., §§ 34, 35.

Before concluding, Mr. Vignoles referred to an able report, in the Archives of the Institution, written in the course of the summer of 1872, by Mr. Walton W. Evans, of New York, one of the most distinguished Engineers in America, in reply to a request from the Agent-General of the British colony of Victoria, to furnish information for the guidance of the government there on the subject of the narrow gauge for railways. This report was most instructing and exhaustive, and recommended itself to the notice of all interested in the present question. The substance was decidedly conclusive against the narrow gauge, for very sufficient reasons assigned, and this was stated to be the opinion of every leading engineer in the United States.

Major-General STRACHEY, by permission of the President, and in explanation, said, that no doubt Mr. Vignoles had brought a great many valuable facts before the Meeting; but that gentleman had mixed up with his facts a certain quantity of statement, which he never would have thought of making if he had been connected with any of the guaranteed railways of India. If that gentleman had been Engineer of any of the guaranteed lines he would never have associated General Strachey's name with the guarantee of Indian railways; he never would have said that he upheld such a financial policy, or that he had been anything but the consistent, and some gentlemen might say the bitter, and even offensive, opponent of that system; therefore he accepted no responsibility for anything that had been done in connection with railway guarantees in India. What, in fact, he had been doing for many years, was to try to obviate the evils that had arisen from that system; and he was in that unfortunate position, that the evils which had arisen from a system of railways, thoroughly incompatible to the country, had now to be corrected, and he was the unfortunate person to bear the brunt.

Mr. J. BRUNLEES read the following observations, and stated, that, as he was not in any way connected with the construction of railways in India, what he had to say on the question before the Meeting was without bias. He had, however, constructed lines on the 3 ft. gauge, the mètre gauge, the 1·1 mètre gauge, the 3 ft. 6 in. gauge, the 4 ft. 8½ in. gauge, and the 5 ft. 3 in. gauge; and he might, therefore, safely say he was not wedded to any one to the exclusion of all others. His opinion was that the gauge was a question of circumstances, and that where it would be wisdom, in one case, to lay a certain gauge, it would in another be the height of folly. Generally speaking, he was in favour of a narrow gauge, say the mètre gauge, for the development of thinly populated countries, and he would

illustrate his meaning by reference to a country with which he had had a great deal to do, namely, Brazil. The first railways constructed there, were on the model of the best European lines, to a gauge of 5 ft.3 in., and their average cost per mile had been more than £20,000. When some 500 miles of line had been constructed at that rate, the Brazilian government reconsidered the whole question, and, he thought wisely, resolved that all future extensions should be on the mètre gauge. The Brazilian empire contained an area of nearly 4,000,000 square miles, with a population of 10,000,000, or 2½ persons per square mile; and it was obvious that if the interior was to be opened up and its great natural resources developed by railways, it must be by means of lines costing much less than £20,000 per mile. By adopting a cheap system of construction, he found that lines of a mètre gauge could be made in Brazil for from £6,000 per mile to £7,000 per mile; and such lines, worked at moderate speeds, and without expensive station buildings and appliances, had met all the requirements of the country. As regarded the lines constructed in Brazil on the broad gauge, he was of opinion that before long it would be found necessary to reduce them to the mètre gauge. It was not more than two years since the mètre gauge was adopted, and many of the lines in course of construction on it started from the coast, and had no connection with the broad-gauge lines, therefore the evils of a break of gauge had not yet been experienced; but, without doubt, they would eventually be experienced, when the Brazilian railway system became further developed. In saying this, he must not be understood as laying down the principle, that a break of gauge was never allowable, but merely that in the case of Brazil, where the mileage of broad-gauge lines constructed was so small, in proportion to that of the narrow-gauge lines which had to be made, it would be absurd not to have uniformity of gauge.

He came now to the question more immediately before the Meeting, and he spoke with some diffidence on it, from not being personally acquainted with India. Still there were facts that were patent to all, and it was on those he should rely. India was little more than one-third the size of Brazil, and its population was between 110 persons and 120 persons per square mile; it required, therefore, much greater facilities in the way of railway communications than those which were proportionate to the requirements of the sparse population of Brazil. His opinion therefore was that both the broad gauge and the narrow gauge were required in India, but under different conditions from those which had hitherto been brought before the Institution.

It was not his intention to go into the question of the relative cost of the broad-gauge lines and of the narrow-gauge lines in India to the extent that had already been done by Mr. Bruce and others. The 5 ft. 6 in. gauge, he thought, would now be admitted to have been a mistake in the first instance, and that, had a somewhat lighter type been adopted, say the 4 ft. 8½ in. gauge, there would not have been any necessity for discussing the advisability of introducing the mètre gauge. His objection to the 5 ft. 6 in. gauge was that it was altogether too heavy for the requirements of a country where the traffic was not concentrated, but had to be picked up in small quantities from numerous stations on a long length of railway. Wagons weighing, when empty, nearly 6 tons were employed in carrying a few bags of grain or logs of dye-wood, or other produce, and the result was that the proportion of the dead to the paying load, carried from and to roadside stations, in India, was excessive. The stations and accessories were, in consequence, on a larger scale than was necessary, while the expenses of the staff were swollen by the number of porters required for shunting and moving the heavy stock about; the locomotive expenses and maintenance being also increased much out of proportion to the traffic conducted.

Five thousand miles of the broad gauge, however, existed, and no one, with the exception of Captain Galton, had the boldness to suggest that they should be in any way interfered with. Mr. Brunlees accepted them as an unavoidable evil, and, in spite of the disadvantages he had enumerated, he was decidedly of opinion that the broad gauge should remain the standard gauge for the railways of India, and that the whole of the seaports, and the chief military stations and commercial centres of the country, should be connected by lines of that gauge. On lines still to be built a saving might, however, be effected by judicious economy in construction. The permanent way might be made somewhat lighter; expensive buildings at stations might be avoided; and, above all, a lighter rolling-stock might be introduced. By these means their cost would be brought nearer to that of the mètre-gauge lines proposed by the Government, and the immense evil of a break of gauge on the main lines or trunk lines of the country would be avoided.

As regarded the mètre-gauge lines, he thought that they should be laid out merely as feeders to the railway system of the country —in fact, taking the place of roads—and should therefore be constructed upon a diminished scale to that proposed by the Government. They should partake more of the character of steam tram-roads. The rails should weigh not more than 30 lbs. per yard;

the engines from 8 tons to 10 tons, and the wagons 1¼ tons empty, with a carrying capacity of 3 tons. The passenger carriages should weigh about 2 tons, and be equal to the accommodation of 20 people. Finally, the speed should not exceed from 10 miles per hour to 15 miles per hour. This might seem a low rate, but it must be remembered that the lines would be used almost exclusively for goods, and by natives, to whom 10 miles a day was now the ordinary rate of travel. No station buildings, beyond sheds, would be needed; and lines of the description he had sketched might, he estimated, be constructed at an average cost of about £3,500 per mile. In short, he believed that, by adopting a plan such as he had suggested, of a system of narrow-gauge lines or tramways, acting as feeders to the main system of broad-gauge railways, these latter would in a very short time pay the guaranteed rate of interest, and the feeders would return a much higher percentage.

Before concluding his remarks, he must make a few observations with reference to the proposal of the Government to construct the Indus Valley railway as a narrow-gauge line. He thought, with the previous speakers, that it would be a grave error to carry out that proposal, the consequences of which it was impossible to estimate.

The Indus Valley railway would, unless the line from Ajmere to Sukkur were constructed, be isolated from the remainder of the proposed narrow-gauge system, and no interchange of stock in cases of emergency would be possible; and it was evident, from what Mr. Lee Smith had said of the nature of the country through which the Ajmere-Sukkur line would pass, that such a line would scarcely pay its working expenses. This being so, the cost of its construction should certainly in part be debited to the Indus Valley railway, as the cost of bringing it into communication with the proposed narrow-gauge system. If this were done, the saving claimed by the Government in the construction of the Indus Valley line as a narrow-gauge line would at once disappear, and an excess as compared with the broad gauge would be exhibited.

It appeared to him, therefore, that so far as that line was concerned, the arguments had utterly failed to show that any economy would arise from the departure from the broad gauge; while the proposal to interpose, on one of the most important strategic lines in the country, a piece of isolated narrow-gauge line, was, to say the least, ill-advised. He had known only one similar instance in practice, and in that case the circumstances were of a peculiar character. He referred to the Mont Cenis summit line, constructed upon a narrow gauge, between the French system of railways at

St. Michel, and the Italian system at Susa. The traffic in this case was chiefly passenger traffic, and, though the break was only for a distance of 50 miles, the inconvenience experienced was most serious. To the development of the goods traffic it was excedingly detrimental. Each ton of goods cost 8*d.* in transhipment, and a day's delay, the station arrangements being very expensive and complicated. In fact, if there had been a great amount of goods to deal with; or had an army, with its baggage, commissariat, ammunition and artillery accompaniments, made its appearance, there would have been inextricable confusion. The experience he gained in connection with that line had convinced him that, on all main lines or trunk lines of communication, break of gauge was an evil to be avoided at almost any cost in the construction.

Mr. SANDBERG said, he had not any experience of the relative merits of the gauges in India, but he would state what had been done in regard to that matter in Sweden. About three years ago a discussion took place between the railway engineers and some members of the government respecting the continuation of the gauge adopted in that country, owing to the railway, on the standard gauge of 4 ft. 8½ in., being considered too expensive. The arguments on both sides were so equally balanced that no decision was arrived at, and the result was that the standard gauge was continued, but the cost was reduced by a lighter construction, which necessitated a lower speed. The main lines had been kept up to the same gauge, and there were about 107 miles of narrow-gauge lines now open. Taking the average cost of the 4 ft.-gauge lines and the 3 ft. 6 in.-gauge lines, the cost of those lines was about £500 per mile cheaper than the 4 ft. 8½ in.-gauge lines with light construction. Railways of the same gauge with heavy construction and adapted for higher speed had cost £7,000 per mile. There had been considerable discussion whether it was advisable to change the gauge to 3 ft. 6 in. He was aware what their neighbours in Norway were doing and while they were converting some of their 4 ft. 8½ in.-gauge lines into 3 ft. 6 in.-gauge lines, the reverse was being done in Sweden. He might state that the opinion of the Swedish engineers generally was, that they had no reason to regret the step they had taken. Great improvement had taken place in the traffic, and from the discovery of coal in the south of Sweden, a large traffic was anticipated, and perhaps the single light 4 ft. 8½ in.-gauge lines would not be sufficient. There was now very little support given to the narrow gauge, in Sweden, and lines which had been proposed on a 3 ft. 6 in. gauge had generally been executed on a 4 ft. 8½ in. gauge. He had recently

published a complete "Account of the Swedish Railways, their Cost, Gauge, and Speed;"[1] a few extracts from which, he thought, might form a useful portion of the Appendix.[2] In conclusion, he wished to state, that he had received a communication from Baron von Weber, M. Inst. C.E., who was an eminent authority, giving his opinion not only on the gauge question in Sweden, but also on that subject for extensive application in Austria, to the following effect:—

"I am exceedingly obliged to you for forwarding me your Report on Swedish railways as to cost, gauge, and speed, and I now beg you to allow me to translate it into German, and add my remarks.

"It comes in very well for me now, as I have formed a Company with large capital for the construction of branch lines in Austria, on the normal gauge of 4 ft. 8½ in., constructed in the most economical manner, and worked at a speed of from 10 kilomètres to 14 kilomètres only. I am at present engaged in enforcing the laws which free railways of this class from all the regulations of traffic and municipal supervision, by which the cost of construction and working is considerably increased.

"Austria, with her mountains and immense agricultural production, is just the country for such railways, and I think I shall be right in carrying out your plans on a large scale. Your Report confirms thoroughly the opinion I have expressed to my Government, and I shall therefore lose no time in publishing it in German, of course giving your name."

Mr. R. PRICE WILLIAMS, speaking from copious notes, said, he should have thought, before hearing the speech of General Strachey, that the estimates brought forward by the Author were rather of a corroborative character, in support of the more detailed and exact estimates upon which, it was to be presumed, the Government had arrived at the grave conclusion to alter the gauge in India. He found, however, he had been mistaken, and that the estimates, if they could be called such, which General Strachey had brought forward in support of the figures given in the Paper, were, if anything, of a more general and vague kind. He gathered from what General Strachey said, in commencing his remarks, that, to some extent, he discredited the Author's assumption of the saving of the narrow gauge, with the qualification that this did not disturb the general conclusions arrived at by the Government; but shortly afterwards he rejected altogether the Author's figures as wholly inapplicable, but still he

[1] *Vide* "Engineering," February 21, 1873.
[2] *Vide* Appendix III.

asserted that the financial advantage secured was great—that it justified the conclusions of the Government. General Strachey then gave his own views of what was likely to be required on an Indian narrow-gauge line, and said, that if mètre-gauge lines, as now constructed, were not able to carry the traffic, the whole argument in their favour failed; while, further on, he affirmed that the narrow gauge was able to carry anything that could be brought on it.

Mr. Price Williams had understood that the chief argument in favour of the adoption of the narrow gauge was, that it provided a means of carrying traffic in localities where the amount was so limited as not to justify the use of ordinary railway plant. So long as the traffic was of that limited character, he considered there would be full justification for its adoption; he would, for instance, suppose the adoption of it in such a country as Norway, where the population was extremely sparse, and where the loads per train were half those of an ordinary-gauge line, in other countries. It was clear, in that case, that rails, sleepers, ballast, weight of engines, &c., must be proportionally reduced; in fact, the line would become, in every respect, a sort of model of the broader gauge to scale, with half traffic to carry. Such lines, in fact, were the admirably designed, and no less admirably constructed lines described by Mr. Carl Pihl; and he could not help regretting that he had not the opportunity of explaining, as he would have done, that he was in no way the advocate of the views which General Strachey put forward, or that narrow-gauge lines constructed for a very limited amount of traffic, such as he had referred to, were at all equal to carry the large traffics of standard-gauge lines. Directly it was contended that these miniature railways could carry any traffic that was brought upon an ordinary-gauge line, the whole argument in their favour completely broke down. In the first place, the weight of the rails, the scantling of the sleepers, the bearing surface on the ballast, and the power and number of engines must be increased to the full proportion required on the broad gauge. The number of vehicles must similarly be increased, and disproportionate running expenses must be incurred.

It had been estimated by General Strachey that the saving to be anticipated from constructing the Lahore-Peshawur line with rails weighing 40 lbs. per yard instead of 60 lbs. per yard, was from £1,000 per mile to £1,500 per mile on the permanent way; 30 per cent. to 40 per cent. saving in cost of ironwork of bridges, besides minor economies of all sorts, which he considered it unnecessary to mention; and he gave, as the total saving on the permanent way of the Lahore-Peshawur line, £350,000, and on the bridges, £280,000;

or say, on the whole, £750,000. The saving on the permanent way of the Indus Valley line he estimated at £500,000, and probably, he said, as much more on other items, making altogether on the Indus Valley a saving of £1,000,000; which, with the saving on the Lahore-Peshawur line, made a grand total of £1,750,000; deducting a round £500,000 for breaks of gauge, it left a total net saving, as General Strachey said, of £1,250,000. Now, it would be seen, that of this estimate £850,000 represented the saving on permanent way alone—£1,300 per mile on the Peshawur line, and about £1,042 per mile on the Mooltan-Kotree line. These figures, General Strachey said, did not take into account the greater economy of maintenance of the narrow gauge, which would probably be in proportion to the greater economy in the first cost.

Now Mr. Price Williams begged to dispute the assumption of greater economy in maintenance. General Strachey, after stating he did not think he was entitled to take it, nevertheless availed himself of this assumed saving in maintenance, on Mr. Hawkshaw's basis, raising the whole amount of saving to about £2,000,000 sterling; £1,600,000 of this was due to saving in construction and maintenance of permanent way, namely, £350,000, permanent way of the Peshawur line; £500,000 ditto, Mooltan-Kotree line; and £750,000 saving in cost of maintenance on both the above lines.

It would not fail to be noticed, that in the estimates both of the Author and of General Strachey, after all, the great bulk of this enormous saving was in the matter of permanent way; and it would be seen that General Strachey's estimate was largely in excess of those given in the Paper.

Returning to the Paper, he demurred entirely to the correctness of the axiom laid down at the outset, that the broad gauge was never adopted except with broad, heavy vehicles, and that on narrow lines comparatively light vehicles were used. Mr. Hawkshaw, upon whose estimates the Author professed to rely, expressly stated in his Report:—"That a very large saving of £2,050 per mile would be obtained by the adoption of a lighter form of engine and a lighter construction of road on the standard light gauge as compared with the standard heavy gauge lines." Mr. Harrison had further drawn attention to the fact that in England there were many lines of that description, and instances could be largely multiplied.

Mr. Price Williams was about to construct a light railway on the standard gauge in the west of Ireland, the circumstances of which he felt had a direct and practical bearing on the subject under discussion. The Irish gauge, as was well known, was very similar to the Indian broad gauge, namely, 5 ft. 3 in. The line

alluded to was about 50 miles in length, and for the greater part a surface line. Its sharpest curve had a radius of 10 chains; its steepest gradient was 1 in 60. It traversed a thinly-populated district, with a small traffic of about £7 per mile per week, necessitating its construction on the lightest possible scale consistent with efficient working. Impressed with this necessity, its promoters consulted him upon the advisability of constructing it on the narrow gauge, and he accordingly prepared estimates foi a light line on the 3 ft. 6 in. gauge, with 40-lbs. rails, as follows:—

IRISH RAILWAYS.

COMPARATIVE COST PER MILE of 5 ft. 3 in. GAUGE and of 3 ft. 6 in. GAUGE.

——	5 ft. 3 in. Gauge.	3 ft. 6 in. Gauge.	Saving by 3 ft. 6 in. Gauge.	Percentage of saving on total saving.
	£	£	£	per cent.
Land	55·20	52·39	2·81	1·35
Earthwork	757·90	661·98	95·92	46·33
Permanent way.	1,081·33	995·25	86·08	41·58
Ditto sidings	26·40	26·40	..	..
Bridges and culverts . . .	83·59	80·18	3·41	1·65
Telegraphs, level crossings, metalling and fencing . .	489·13	489·13	..	..
Stations	145·30	145·30	..	..
	2,638·85	2,450·63	188·22	90·91
Contingencies 10 per cent. .	263·88	245·06	18·82	9·09
	2,902·73	2,695·69	207·04	100·00
Deduct for additional cost of renewals of permanent way per annum capitalized (*vide* Table, p. 131)	..	..	267·41	
Balance in favour of the 5 ft. 3 in. gauge	..	..	60·37	per mile.

He would not trouble the Meeting with the details of these estimates; it would suffice to state that they showed a saving per mile

on the narrow gauge of £207, or 7½ per cent. on the total cost of construction, which was very much about the amount of saving which Mr. Bruce mentioned as having been estimated in the case of a light railway in India. Of this total amount of saving, a little more than 1 per cent. represented the saving in land; 46 per cent. in earthwork; 41 per cent. in permanent way, and about 1½ per cent. in bridges; the latter being few and unimportant. With regard to the 41 per cent. saving in permanent way, the principal item was the saving in sleepers. He adopted for the narrow gauge the scantling of sleepers given in Mr. Fowler's estimate for the Mooltan-Kotree line, namely, 9 in. × 4½ in., in order to show the largest possible saving that could be calculated upon. He prepared also the following estimate of the relative cost of maintenance and renewals on both gauges:—

IRISH RAILWAYS.

COMPARATIVE COST of MAINTENANCE and RENEWALS of PERMANENT WAY upon the 5 ft. 3 in. GAUGE and upon the 3 ft. 6 in. GAUGE.

—	5 ft. 3 in. Gauge.							3 ft. 6 in. Gauge.						
	Cost per mile.			Life.	Annual Cost of Renewals.			Cost per mile.			Life.	Annual Cost of Renewals.		
	£	s.	d.	yrs.	£	s.	d.	£	s.	d.	yrs.	£	s.	d.
Rails (42 lbs.)	598	10	0	25	23	18	10	598	10	0	25	23	18	10
Fish plates	52	10	0	25	2	2	0	52	10	0	25	2	2	0
Fish bolts	17	10	0	25	0	14	0	17	10	0	25	0	14	0
Spikes	31	10	0	10	3	3	0	31	10	0	6	5	5	0
Sleepers:—														
8 ft. 6 in. × 9 in. × 4½ in.	205	6	8	10	20	10	8	..			..	..		
6 ft. 9 in. × 8 in. × 4 in.	..			..	..			132	0	0	6	22	0	0
Ballast:—														
Top	44	0	0	10	4	8	0	37	12	6	6	6	5	5
Bottom	44	0	0	..	..			37	12	6	..	..		
Labour to renewals:—														
Rails	44	0	0	25	1	15	2	44	0	0	25	1	15	2
Sleepers	44	0	0	10	4	8	0	44	0	0	6	7	6	8
£	1,081	6	8		60	19	8	995	5	0		69	7	1
Labour to ordinary maintenance, packers, &c.	..			..	36	0	0	..			..	41	0	0
				£	96	19	8				£	110	7	1

ANNUAL COST of MAINTENANCE and RENEWALS of PERMANENT WAY.

	£	s.	d.	
3 ft. 6 in. gauge	110	7	1	
5 ft. 3 in. gauge	96	19	8	
Extra cost of maintaining the 3 ft. 6 in. gauge	£13	7	5	per annum.
Twenty years' purchase of	£13	7	5	= £267 8*s.* 4*d.*

The extra cost of maintenance and renewals on the narrow gauge was £13·37 per mile, which, capitalised at 20 years, represented £267 8*s.* 4*d.*; the saving in cost of construction, as already explained, being £207, leaving a balance against the narrow gauge of £60 per mile. He should state that the cause of the increased cost of maintenance and renewal on the narrow gauge, under similar conditions and amount of traffic, was entirely owing to the smaller scantling of the sleepers, and for the following reasons. The life of rails, as was well known, was measured by the tonnage and the speed, or 'speed tons,' as they were called. The same held good as to the life of sleepers. The additional element of the natural decay of the wood had also to be taken into account. Assuming the amount of traffic to be the same on both gauges, it was evident that the life of the rails would be the same; and assuming the scantling of the sleepers on the narrow gauge to be smaller than that of those on the broad gauge, and the amount of traffic in both cases to be the same, it followed that the life of the sleeper of the smaller scantling would be the shortest. The life of a common larch sleeper, of the scantling referred to, was 10 years for the larger sleeper, and 6 years for the smaller sleeper. The smaller scantling sleepers, as was usually the case, consisted of the top portions of the trees, and the wood was consequently more sappy and perishable. It followed, therefore, that under a given amount of traffic, any reduction of scantling of the sleepers was necessarily attended with additional cost of maintenance and renewal of way, as renewals were more frequently required. The natural inference to be drawn from all this was, that it really was more economical to use the better and costlier material, even for these narrow-gauge lines. It was obvious, if the smaller scantling would do for the narrow gauge, it would do for the broad gauge under a similar amount of traffic. It might be argued that the broad gauge required a sleeper 2 ft. 3$\frac{5}{8}$ in. longer than the mètre gauge. That was not so, as the bearing surface upon the ballast was proportionate to the load carried, and quite independent of the gauge; consequently, what was a sufficient bearing surface in the one case was absolutely necessary in the other: for instance, if there was a longer sleeper in the one case, it was essential to have a broader one in the other. There was this additional advantage in the longer sleeper, that the load was distributed over a wider surface of ballast, ensuring greater stability, and requiring less frequent packing of the road. He would point out what seemed hitherto not to have been referred to, namely, that where longitudinal timber sleepers, or iron pot sleepers were used—and he understood they were being used to

	Saving per Mile 3 ft. 6 in. Gauge, compared with 5 ft. 6 in. Gauge.			Mr. Thornton's Estimate as adjusted for the Mètre Gauge.	Total Saving on 10,000 Miles of Railway as per Mr. Thornton.	Percentage on Total Saving.
	Mr. Fowler.	Mr. Hawkshaw.	Mr. Thornton.			
	£	£	£ s.	£	£	per cent.
Land	..	10	10 0	10·1626	101,626	1·02
Earthwork	37	100	average 68 10	69·6138	696,138	6·96
Bridges	83	50	,, 66 10	67·5812	675,812	6·76
Sleepers and ballast, &c.	503*	200	,, 352 0	357·7238	3,577,238	35·77
Sleepers . . . £308						
Ballast . . . 140						
Laying . . . 10						
10 per cent. for Sidings . . 45			497 0			
*£503						
Engineering and agency	87	..	87 0	88·4146	884,146	8·84
Maintenance and renewals of permanent way	..	200	200 0	203·2520	2,032,520	20·33
Add saving by sharper curves in earthwork	..	200	200 0	203·2520	2,032,520	20·32
Total	710	760	984 0	1,000·0000	10,000,000	100·00
Actual average	$\underbrace{\qquad}_{735}$					

a large extent in India—there was no saving whatever as between broad-gauge lines and narrow-gauge lines in that respect.

Returning to the estimates—he would draw attention to the Table (p. 133) as showing that the actual average saving was £735 per mile, and not £984 per mile, as was made to appear in the Paper.

What had really been presented in the Paper was a maximum estimate, or nearly so, as might be seen from a reference to the following tabular statement, in which he had given, on the one hand, all the largest items in Mr. Hawkshaw's estimate and in Mr. Fowler's estimate; and on the other hand, all the small items. The maximum estimate of saving was thus shown to be £1,183 per mile, or very little more than the Author's estimate; while the minimum estimate only amounted to £287 per mile; and, supposing the wish to be father to the thought, it was quite open to the Author to have taken the smaller estimate. Mr. Price Williams would particularly direct attention to the fact that, in the estimates both of the Author and of General Strachey, the great bulk of the estimated saving was in the item of permanent way.

It would be seen that the saving in the cost of construction of the permanent way was estimated, by the Author, at 36 per cent.; and in addition to this, a further saving of 20 per cent. was shown in the item of maintenance; making altogether 56 per cent., which would represent considerably more than half of the total estimated saving of £10,000,000.

——	Maximum Estimate. Per Mile.		Minimum Estimate. Per Mile.	
		£		£
Land	Mr. Hawkshaw	10	Mr. Fowler	..
Earthwork	,,	100	,,	37
Bridges	Mr. Fowler	83	Mr. Hawkshaw	50
Sleepers and ballast, &c.	,,	503	,,	200
Engineering and agency	,,	87	,,	..
Renewals of permanent way	Mr. Hawkshaw	200	Mr. Fowler	..
Additional saving, by sharper curves in earthwork	,,	200	,,	..
		£1,183		£287

In General Strachey's estimate, the saving in the cost of permanent way on the Peshawur line and on the Mooltan-Kotree line was considerably higher, amounting, as far as Mr. Price Williams could make out, to 75 per cent. It should be remembered, that the

Author's estimate of saving on the permanent way was entirely dependent upon the adoption of sleepers of the smaller scantling, as given in Mr. Fowler's estimate, the adoption of which must inevitably result in a large addition to the annual cost of maintenance and of renewals consequent upon the shorter life of the sleepers, and, to a certain extent, in extra cost of repairs due to the greater instability of these narrow-gauge lines when subject to similar conditions and amounts of traffic. Mr. Price Williams found, from Mr. Lee Smith, that the life of ordinary sleepers used in that part of India was much about that which he had given. Assuming, therefore, in the Author's estimate, the same scantling sleepers to be used in both cases, this saving in first cost entirely disappeared, and with it, of course, the 20 per cent. saving in maintenance also. He would, at the same time, draw attention to the fact that Mr. Fowler made no claim at all for extra cost of maintenance. No one knew better, indeed, than Mr. Fowler that, under a given amount of traffic, the more lightly-timbered permanent way must necessarily be the more expensive to maintain and renew. With regard to the saving in ballast, all that could possibly be claimed was the saving of the central strip of 2 ft. $3\frac{5}{8}$ in., representing the extra width of the broad gauge. As to the 1 ft. 3 in. estimated depth of ballast for the broad gauge, if 1 ft. would do for the one gauge, it was obviously sufficient for the other; and if the sleepers were the same length in both cases —as Mr. Price Williams maintained they should be—that item of saving also disappeared, and with it the entire saving in earthwork, as the width of formation required would then necessarily be the same. With regard to the £45 per mile saving for sidings, the greater number of vehicles would require greater length of sidings, so that there could clearly be no claim under this head. Then there was the item of engineering and agency, which, after the very large deductions he had already made in the total estimated amount of saving, would necessarily be very much reduced also. There now only remained the large item of 20 per cent. saving on earthwork, by having sharper curves and heavier gradients. Mr. Hawkshaw, he thought, had already disposed of that.

Mr. Price Williams would notice, however, that no account had been taken in the estimates for the additional length of line due to these sharper curves, which, if it were taken at only 10 per cent., would amount to an additional cost of £175 per mile on the Mooltan-Kotree line. No claim had been made by the Author, or by the other advocates of the narrow gauge, for saving in respect of the rolling-stock, either in cost of construction or maintenance; all the experience on this subject showed conclusively, that there was

no real economy in constructing the framing of rolling-stock on too slight a scale, even for these light lines. He might state he had availed himself of an opportunity afforded him of examining the drawings of rolling-stock for both broad guage and narrow gauge in India, and he had been struck with the exceedingly slight character of the framing of the carriages and wagons designed for the mètre gauge. With the view of satisfying himself on this point, he had been at the trouble of taking out the quantities of timber in each case with the following results:—The quantity of timber in a low-sided truck, of the standard gauge, with a carrying capacity of 338 cubic feet, was 86 cubic feet of timber; while the low-sided truck, of the mètre gauge, on the Indian lines, with a carrying capacity of 168 cubic feet, had only 45 cubic feet of timber in it. It would be seen from this, that the carrying capacity of the standard-gauge truck was just double that of the mètre-gauge truck, and that the cubic quantity of timber in each was very much in a similar proportion, so that there was obviously no saving in dead load.

He would now say a few words upon the running expenses on the narrow gauge, of which no notice had hitherto been taken. In considering these estimates, it was obvious that the greater number of vehicles required to carry a given load on the narrow gauge would require either more powerful and heavier engines, or duplicating the trains. In the first place, he would ask what would happen to the iron girder bridges which General Strachey spoke of reducing to the extent of something like 30 per cent. to 40 per cent. In the latter case it was evident the cost of the extra rolling-stock would have to be taken into account, and also the additional running expenses, which would be greatly increased. Much had lately been said and written, as to the saving in dead load on the narrow-gauge lines. Figures had been freely quoted, showing the proportion of the dead load to the live load, or paying load, on the broad-gauge lines to be in the proportion of 5 to 1, while the proportions on the narrow-gauge lines were shown to be only 1½ to 1. He thought it was now necessary that such loose and unfounded statements should be exploded. He could state, from his own investigation on this subject, on the rolling-stock of the Great Northern railway, that anything like that ratio of dead load to live load did not obtain; while in the case of the light standard-gauge rolling-stock and the light mètre-gauge rolling-stock there was, as he had already shown, nothing to prevent the ratio of the dead load to the paying load being identical in both cases. He believed nothing had more commended these narrow-

gauge lines to public favour and consideration than this alleged saving of dead weight, and consequent economy of construction and working. It was easy to gather, from what Lord Lawrence said, that the chief motive which had induced the Government of India to sanction the adoption of the narrow gauge, was the idea of its greater economy in construction and working; and as far as the motive was concerned, it was one deserving of the highest respect and consideration. At the same time, it was, in Mr. Price Williams' opinion, evident that what had been decided on must inevitably result in defeating the very object sought to be obtained. It would also not fail to have been noticed, that Lord Lawrence, while admitting his inability to deal with the engineering data upon which these estimates of saving were based, yet appeared to rely implicitly upon and to believe in the reality of this large saving—which Mr. Price Williams ventured to think had been conclusively shown not to exist. Lord Lawrence, in fact, spoke of the broad gauge as costing £12,000 per mile, and the narrow gauge £7,000 per mile. Those figures representing, it would be remembered, General Strachey's own estimates of the cost of a broad-gauge line with 60-lbs. rails, and a narrow-gauge line with 40-lbs. rails. It was notorious that they had as yet no reliable experience of the actual cost of maintenance and working of these narrow-gauge lines; indeed, sufficient time had not elapsed since their first introduction to allow of any just conclusion being arrived at as to the cost of working them. What little experience they had in regard to the Festiniog line seemed to bear out very strongly the view Mr. Price Williams took, namely, that although there might be a slight saving in the cost of construction of the works of the line, &c., still the narrow gauge must necessarily be more expensive in maintenance and renewals; and he should have been glad if Mr. Spooner had afforded the Meeting some explanation of the very disproportionate cost of the working expenses on that line, to which Mr. Harrison had drawn attention.

It was as well to bear in mind the great difference in the circumstances of light railways in Great Britain and in India. In this country they were intended to serve as branches and feeders to the main lines, and as such, he believed, they were destined to fulfil a very important function, in developing the resources of large agricultural districts at present almost entirely deprived of railway communication. In India, at all events, the majority of the lines that had been constructed or proposed partook really of the character of main or arterial lines, destined to serve large districts with vast populations. Mr. Price Williams would

take, for instance, the Punjâb railways, which had the unenviable distinction of being made the battle-field of the gauge question in India. Its mileage from Kurrachee to Lahore alone exceeded the distance from one extremity of the United Kingdom to the other; and from a reference to the valuable statistics he had access to, relating to the population of India, he found that the population of Scinde and the Punjâb, in 1870, amounted to 19,392,346, or very little short of that of England and Wales. Again, he found that the Madras Presidency, through which the projected coast line passed, had a population of 31,312,000—a population equal to that of the whole of the United Kingdom—while the population of Bengal, the North-Western Provinces, and Oudh, served by the railways on the East of India, amounted to about 108,000,000; while that of the Bombay Presidency and the Central Provinces, served by the Great Indian Peninsula railway, amounted to nearly 22,000,000. He therefore thought it was open to grave question whether, quite irrespective of this gauge question, the construction of these lines, on the very light scale proposed, was such as to provide for the future development of the traffic on the Indian railways. He did not now refer to the light character of the permanent way and rolling-stock; these could be replaced, when they had served their purpose, by heavier materials and by heavier stock, as had been the case on the railways in Great Britain and in the United States; but the question was, whether from a desire to realise a doubtful economy on the first cost, a serious restriction would not be placed upon the traffic to be hereafter developed? Whether, in fact, it would not be better and cheaper, in the end, at once to make—on the principal arterial lines at least—the same wise provision for future development of the traffic already made on some of the older lines, which, although at present worked as single lines, had the viaducts and bridges constructed for a double line? He would be glad to know if there was anything in the circumstances of the country or of the people to warrant the assumption that the same law of development would not obtain in India as in this and other countries. It did not require to have spent a lifetime in India in order to know what were the nature and circumstances of the existing railways in India. It was understood that they were not paying. He was disposed to think it was unreasonable to expect they would prove immediately remunerative.

The results he had been able to arrive at, from a careful exami-[illegible]n of the valuable statistics relating to the Indian railways [illegible]red by Mr. Juland Danvers, were, he considered, highly en-

couraging, and already showed remarkable indications of that progressive development to which he had just referred. Mr. Price Williams had prepared the following diagram (Fig. 1) and the tabular statement (page 140) from those sources:—

FIG. 1.

INDIAN RAILWAYS.

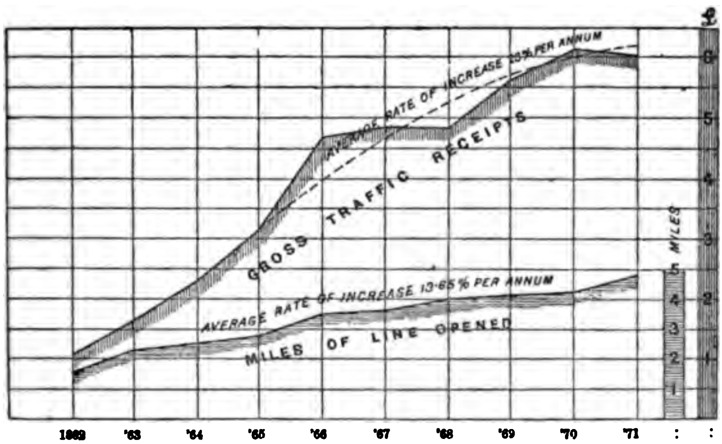


DIAGRAM SHOWING INCREASE OF TRAFFIC, 1862–1871.

Average annual increase of traffic	23·00	per cent.
" " miles of line..	13·65	"
" " traffic per mile	8·23	"

Without entering into details, he might mention that, in a period of nine years, from 1862 to 1871, the mileage of railways open for traffic in India had increased from 1,584 to 4,778, or on the average a little more than 13½ per cent. per annum; the number of passengers had increased from 7,151,650 to 17,982,892, or on the average 12 per cent. per annum; the passenger receipts from £446,872 to £1,870,142, giving similarly an average of 18½ per cent. per annum; the goods receipts from £609,571 to £4,137,964, or an average of 26⅔ per cent.; while the gross traffic receipts had increased from £1,056,443 to £6,008,106, or an average during that period of 23 per cent. per annum. After making every allowance for the slight falling off in the receipts which had occurred in the last two years, the average growth of traffic on a fixed mileage had exceeded 8 per cent. per annum during those nine years. This rate of increase far exceeded

INDIAN RAILWAYS.—INCREASE per Cent. of MILEAGE opened, PASSENGERS CONVEYED, and RECEIPTS from PASSENGER TRAFFIC, GOODS TRAFFIC, and TOTAL TRAFFIC, from 1862 to 1871.

Year.	Length of Line Opened.	Increase per Cent.	Passengers Conveyed.	Increase per Cent.	Receipts from Passenger Traffic.	Increase per Cent.	Receipts from Goods Traffic.	Increase per Cent.	Total Receipts.	Increase per Cent.
	Miles.	Per Cent.	Number.	Per Cent.	£	Per Cent.	£	Per Cent.	£	Per Cent.
1862	1,584	.. ..	7,151,650	.. ..	446,872	.. ..	609,571	.. ..	1,056,443	.. ..
1863	2,234	+ 41·03	9,202,944	+ 28·68	686,508	+ 53·63	961,532	+ 57·74	1,648,040	+ 56·00
1864	2,581	+ 15·53	11,631,683	+ 26·39	974,370	+ 41·93	1,328,874	+ 38·21	2,303,244	+ 39·76
1865	2,747	+ 6·43	12,826,518	+ 10·27	1,302,432	+ 33·67	1,815,243	+ 36·60	3,117,675	+ 35·36
1866	3,452	+ 25·66	10,120,910	− 21·09	1,278,580	− 1·83	3,328,656	+ 83·39	4,607,236	+ 47·78
1867	3,597	+ 4·20	13,752,591	+ 35·88	1,465,403	+ 14·61	3,386,789	+ 1·75	4,852,192	+ 5·32
1868	3,992	+ 10·98	15,061,677	+ 9·52	1,591,475	+ 8·60	3,239,920	− 4·34	4,831,395	− 0·43
1869	4,023	+ 0·78	16,063,594	+ 6·65	1,742,761	+ 9·51	3,797,558	+ 17·21	5,540,319	+ 14·67
1870	4,182	+ 3·95	17,179,230	+ 6·94	1,847,249	+ 5·99	4,229,713	+ 11·38	6,076,962	+ 9·69
1871	4,778	+ 14·25	17,982,892	+ 4·68	1,870,142	+ 1·24	4,137,964	− 2·17	6,008,106	− 1·13
		+122·81	.. ..	+129·01	.. ..	+169·18	.. ..	+246·28	.. ..	+208·58
		.. ..	.. ..	− 21·09	.. ..	− 1·83	.. ..	− 6·51	.. ..	− 1·56
	9)	+122·81	.. .. 9)	+107·92	.. .. 9)	+167·35	.. .. 9)	+239·77	.. .. 9)	+207·02
	Average	+ 13·65	.. ..	+ 11·99	.. ..	+ 18·60	.. ..	+ 26·64	.. ..	+ 23·00

Normal Increase of Receipts with a constant Mileage $= \dfrac{23{\cdot}00 - 13{\cdot}65}{1 + \dfrac{13{\cdot}65}{100}} = 8{\cdot}23$ per cent. per annum.

that which had obtained on the railways of the United Kingdom, where, as would be shown by the following diagram (Fig. 2), and the tabular statement (page 142), the rate of increase on a fixed mileage, in a period of twenty-two years, had not exceeded 2½ per cent. per annum.

Fig. 2.

RAILWAYS OF THE UNITED KINGDOM.

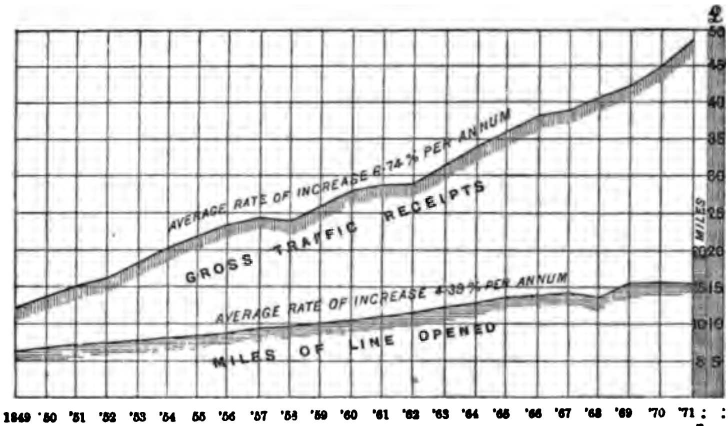


Diagram showing Increase of Traffic, 1849–1871.

Average annual increase of	traffic	6·74	per cent.
,, ,,	miles of line	4·39	,,
,, ,,	traffic per mile	2·25	,,

STATEMENT showing the INCREASE per Cent. of the GROSS RECEIPTS and MILES of LINE of the RAILWAYS of the UNITED KINGDOM from 1849 to 1871. (Extracted from the Board of Trade Returns.)

Year.	Total Gross Receipts from all sources.	Increase per cent.	Miles of Line.	Increase per cent.
	£	per cent.	miles.	per cent.
1849	11,806,498	..	6,032	..
1850	13,204,669	+ 11·85	6,621	+ 9·76
1851	14,997,459	+ 13·57	6,890	+ 4·06
1852	15,710,554	+ 4·76	7,336	+ 6·47
1853	18,035,879	+ 14·80	7,686	+ 4·77
1854	20,215,724	+ 12·09	8,053	+ 4·78
1855	21,507,599	+ 6·39	8,335	+ 3·50
1856	23,165,493	+ 7·70	8,710	+ 4·50
1857	24,174,611	+ 4·36	9,447	+ 8·46
1858	23,956,751	− 0·90	9,542	+ 1·01
1859	25,743,502	+ 7·46	10,002	+ 4·82
1860	27,766,622	+ 7·86	10,433	+ 4·31
1861	28,565,355	+ 2·87	10,865	+ 4·14
1862	29,128,558	+ 1·98	11,551	+ 6·31
1863	31,156,397	+ 6·96	12,322	+ 6·67
1864	34,015,564	+ 9·18	12,789	+ 3·79
1865	35,890,113	+ 5·51	13,289	+ 3·91
1866	38,164,354	+ 6·34	13,854	+ 4·25
1867	39,479,999	+ 3·45	14,247	+ 2·83
1868	40,912,534	+ 3·63	13,803[1]	− 3·12
1869	42,695,927	+ 4·36	15,145	+ 9·72
1870	45,078,143	+ 5·58	15,537	+ 2·59
1871	48,892,780	+ 8·46	15,376[1]	− 1·04
		+149·16		+100·65
		− 0·90		− 4·16
	22)	+148·26	22)	+ 96·49
	Average	+ 6·74	Average	+ 4·39

$$\text{Normal increase of Receipts with a constant mileage} \quad \Big\} = \frac{6\cdot74 - 4\cdot39}{1 + \frac{4\cdot39}{100}} = 2\cdot25 \text{ per cent. per annum.}$$

He ventured to think that the fact, that the Indian railway traffic was actually growing at a rate which would double itself in every ten years was most significant, and that it had a most important bearing upon the question now under discussion.

Indeed, it was impossible not to see that, with the large resources in coal and other products, and with its enormous population of nearly 200,000,000, a rapid development of traffic and industrial energy must necessarily follow the introduction of railways in the

[1] These apparent decreases in the mileage are owing to certain alterations in the methods of making the Returns to the Board of Trade.—R. P. W.

large and populous districts in India at present wholly deprived of the facilities afforded by railway communication.

Looking to all these circumstances, there could be no doubt, he contended, that these narrow-gauge lines would be incapable of meeting the demands that would be made upon them by the future development of the traffic of the country.

After what had been so forcibly urged against the break of gauge by Mr. Allport, it was scarcely necessary for Mr. Price Williams to refer to it; but having been connected for the greater part of his life with the particular district which had suffered so much from the effects of this break of gauge, he ventured to say that it was impossible to exaggerate the evils attending it, and that to estimate the money value of the cost, or loss, resulting from a break of gauge at anything like the figure quoted by the Author was simply absurd.

Mr. Price Williams might mention that it was owing to this unfortunate break of gauge that the large resources in good house coal, which the South Wales coal-field possessed, had hitherto been excluded from the London market. The South Wales coal-field, as was well known, was nearly twenty miles nearer London than the Yorkshire coal-field. He might add, that since the Great Western Railway Company had completed the alteration of their line, from London to South Wales, to the standard gauge, a great impetus had been given to the house coal trade in that district, and there was now every prospect of the Welsh coal finding its way into the London market.

The Author, in bringing this important question before the Institution, had fairly challenged the opinions that had been expressed upon it. As a Member of that Institution in no way connected with Indian railways, either professionally or otherwise, Mr. Price Williams had ventured to express his firm conviction, founded upon the results of a long practical experience in this particular part of the subject, that so far as the estimated saving in the permanent way was concerned, it was entirely fallacious. General Strachey had seen fit to remind them that the opinions of the members of this Institution formed but one element in this important question: what the other element was, it was unnecessary for him to inquire. He felt assured, however, that the weighty arguments that had been urged against the adoption of these narrow-gauge lines in India would have their full weight with the Government of India, and that when they had the Paper, with the discussion upon it, before them, they would not fail to recognise the force of Mr. Hawkshaw's

suggestion—not to proceed further with their programme of constructing these 10,000 miles of narrow-gauge lines until they had made some more thorough and efficient inquiry as to the soundness of the data upon which these large estimated savings rested.

Mr. A. M. RENDEL read the following remarks. Although he was in no way responsible for the Paper which formed the subject of this debate, and, indeed, was not aware that it was in contemplation until it had reached the Institution, still, as entirely sympathising with its Author, and, in common with other members, having been called upon to make observations upon the policy it supported, he did not hesitate to give his views.

He wished, in the first place, to set the Committee of 1870, of which he was a member, right with the Institution in regard to the charge which Mr. Bidder brought against it of being 'packed. Mr. Bidder appeared to suppose that the committee was appointed by the Government to give an opinion in favour of a conclusion which the Government had already arrived at, and that, for that purpose, the persons placed upon it were selected either from those who were known to hold certain opinions, or from those upon whose docility the Government could rely. Unless this was Mr. Bidder's supposition, the accusation had no point, and if it were so, then he declared that the charge was groundless. A perusal of the reports of the committee would have shown that the duty intrusted to it was not to consider the general question of whether a narrow gauge should be introduced into India. The Government had long made up their minds that for the future the ruling gauge should not exceed 3 ft. 6 in., and the members of the Committee were so informed in the instructions, and all that they were asked to do was to consider whether a still smaller gauge might not be adopted. Now to put on a committee appointed for such a purpose men who were notoriously of opinion that the gauge should be a great deal more than 3 ft. 6 in. — that is to say, 5 ft. 6 in., and nothing else—would have been simply absurd. Common sense dictated the necessity of appointing the members from amongst those persons who might be expected to support a narrow gauge.

But, narrow as the duties were, the Committee could not agree. Mr. Fowler insisted on a 3 ft. 6 in. gauge and a 45-lbs. rail; the rest of the members—Colonel Strachey, Colonel Dickens, and Mr. Rendel—urged a 2 ft. 9 in. gauge, and a 36-lbs. rail. Now, out of this difference of opinion arose that little trip to Norway to which Mr. Bidder had alluded, and which was planned by

Mr. Fowler in the hope that the actual sight of a line of 3 ft. 6 in. gauge at work would have a certain effect in its favour on the untutored minds of his colleagues. Unfortunately, the inspection had precisely the contrary effect; for they came away more strongly impressed than ever in favour of their own views.

The Norwegian railways of 3 ft. 6 in. gauge were, no doubt, most excellent of their kind—'toys' Mr. Andrew would call them—but there was no doubt that their capacity for traffic was in excess of the traffic ever likely to come upon them.

A high average traffic on a Norwegian narrow-gauge line would be represented by about 100 passengers and 40 tons of goods passing over the whole of each line daily; and Mr. Rendel did not think there was much probability of any great increase on this—at all events at an early date. The speed at which this traffic was run was 14 miles per hour. There was, therefore, nothing in the amount of the traffic nor in the speed at which it was run, nor was there anything in its character, to require a gauge as large as 3 ft. 6 in., or a rail as heavy as 36 lbs. Why, then, did Mr. Pihl, on determining to abandon the 4 ft. 8½ in. gauge, take his stand at 3 ft. 6 in. gauge? Partly, Mr. Rendel ventured to think—saying it with the highest respect for him—because he was wanting in the courage of his opinions, and partly because he put too much faith in a certain firm of locomotive builders who told him they could not build a satisfactory engine on a smaller gauge.

Old-established locomotive firms were, in his experience, the most conservative people on the face of the earth, and for his own part, he made a point of never accepting their advice, merely because it was their advice, in any matter out of the line of their ordinary daily practice. The heating surface of the largest Norwegian engines was only 400 square feet; and, though the gradients were bad, the ordinary traffic could hardly utilize as much. He found no difficulty in placing as much as 600 square feet of heating surface on the mètre gauge; he could put nearly as much on a 2 ft. 9 in. gauge; and he was satisfied that the bulk of the railways to be built on the mètre gauge in India would not, as a rule, utilize as much as 300 square feet of heating surface.

Each section of the Committee made its report, and the reports went to India for Lord Mayo's consideration; and very sorry Mr. Rendel was when he heard that Lord Mayo, with his natural conservative dread of extremes, had levelled the 2 ft. 9 in. gauge up to 3 ft. 3⅜ in. That was to 1 mètre.

Mr. Rendel would here remark, that he was somewhat surprised at the misunderstanding which had been exhibited in regard to the

reasons for adopting the mètre. The simple reason for doing so was, that at the time the gauge was settled it was the intention of the Government of India to adopt for India the French system of weights and measures. It was only natural, therefore, it being Lord Mayo's intention to adopt something between 3 ft. and 3 ft. 6 in., that he should determine to take the mètre; and all the drawings, he might observe, were drawn to the metrical scale.

Now, what was the case for the narrow-gauge system in India? It was presumptuous on his part to re-state it after Lord Lawrence; but for the sake of repetition he would do so. India was a country containing some 1,500,000 square miles—about 30 times the area of England. It was a populous country, but it was an almost purely agricultural country; and being at once populous and agricultural, it was a poor country. England had about 11,000 miles of railway, besides innumerable well-built roads, and long lengths of canal. India had only 5,000 miles of railway; her roads were few and far between, of a kind which would be laughed at in England—dear to make, dear to maintain, dear to work, and impassable at some seasons—and it had next to no canals. The commerce of the country was confined, in fact, to the neighbourhood of great rivers where water carriage was obtainable, and if the bulk of the country was to be brought within the pale of commerce—within, he might say, the pale of European civilization—it could only be so brought by railways. But the country being so vast and so poor, the lengths to be traversed being so great, and the traffic—as experience showed—being extremely small as compared with the capacity of a railway for traffic, it followed that the railways must be as cheap as possible, and might be, and for the sake of cheapness should be, as small as they could be made. Long railways, and not broad railways, were what were wanted, and breadth was dearly purchased at the expense of length. Any railway whatever would give the country all the necessities and all the comforts of railway locomotion; the luxuries and refinements of a more advanced country like England might be left till the traffic could pay for them. In the meantime, the conditions under which the traffic of the country was conducted were such that the want of such refinements would never be felt. That was the view which guided the report which Colonel Strachey, Colonel Dickens, and Mr. Rendel signed, recommending the 2 ft. 9 in. gauge, and a 36-lbs. rail. They considered that to adopt the larger gauge and the heavier rail recommended by Mr. Fowler would be simply to throw away money without any corresponding advantage. If a second gauge

was to be introduced, it was clear that it should be the smallest which could do the work.

Now what was alleged against their view? Why, that before all, and above all, there must be unity of gauge; that there must, under no circumstances, be any departure from the present 5 ft. 6 in. gauge, and that the 5 ft. 6 in. gauge could be retained at a very small extra cost over the narrow guage. No doubt those who had increased the narrow gauge from 2 ft. 9 in. to the mètre, and the rail from 36 lbs. to 40 lbs., had done their best to help this view.

The proposition made by some members of the Institution was, as he understood it, to maintain the 5 ft. 6 in. gauge, but to reduce its rail to somewhere about 40 lbs., and it was alleged that with such a rail, at all events, the rolling-stock could be used, and in emergencies, with care, the locomotive stock of the present broad-gauge lines could be employed.

As to the mechanical part of the matter, he had to observe that, when the London and North Western Railway Company were using 13-ton engines, they were also using 65-lbs. rails, and were laying down 75-lbs. rails, and that a 9½-ton engine on the Liverpool and Manchester line threatened the existence of 35-lbs. rails until it was supplied with 3 pairs of wheels. The evidence given before the Gauge Commission in 1846 would corroborate this statement.

Again, he had to observe that a 42-lbs. rail on a broad-gauge line in India was no new thing. It was tried on the Oudh and Rohilkund, broke down under the wagons of the East Indian railway, and was taken up and replaced by a 60-lbs. rail; he knew that it is alleged that the failure was owing to conical wheels being run on flat rails. He did not believe this was the cause of the failure, and he did not believe that any one here would say it was so.

But, assuming that a 40-lbs. rail could be used, the case contended for was that the rolling-stock of the broad-gauge lines, intended to carry and which would soon carry 10 tons per wagon, was far too big for the traffic of the country which the narrow-gauge lines would traverse; that if a special rolling-stock was built for the light lines, it would be economical for neither broad gauge nor narrow gauge, and that transhipment would be resorted to, even if break of gauge was not admitted.

But Mr. Rendel said much more than this. He said that 40-lbs. rails were not obligatory. If the weight could be reduced on the 5 ft. 6 in. gauge, it could also be reduced on the narrower gauge. The 40-lbs. rail was the maximum, and in his view quite unneces-

sarily heavy. He hoped to carry railways into such out-of-the-way and now desolate districts that he could use rails of something like half that weight. Indeed 30-lbs. rails had already been supplied for one line, and if iron remained at anything like its present price, he for one should recommend the Government to do so generally very soon, for he was satisfied that they were using too heavy a rail. There was a narrow-gauge line now at work in India, about 150 miles from Calcutta, which had only a 32-lbs. rail. The traffic on this line was as heavy as that of many lines the Government would construct, and it had been open for, he thought, nearly ten years. He maintained, therefore, that, even supposing the 40-lbs. rail could be employed on the broad gauge, it would fall far short of the economy which might be effected by means of the narrow gauge.

He should very much like to know what Mr. Bidder would have said if the Government had proposed a 40-lbs. rail on his 'missing link.' He would undertake to say that, with his usual freedom of speech, he would have told the Government their officers were fools, and knew nothing about their business. And how did Mr. Bruce reconcile his proposal with his actual conduct? That gentleman was the Engineer of a line in the south of India which had no political importance whatever, and very little commercial importance. Up to the date of the Government decision to adopt for the extension of that line the narrow gauge, he was supplying it not only with 68-lbs. rails, but with the most expensive form of permanent way generally he could devise—a 'bowl sleeper' road. Now he came and told the Meeting that a 40-lbs. rail on a small wooden sleeper would have done. If so, why did he not propose it before? Of course Mr. Bruce was too shrewd a man not to see his own inconsistency, so he endeavoured to account for it, and how did he do so? Why, he said that economical propositions were not favourably received by the Government, in support of which he quoted some trumpery case about the level of certain platforms.

It was the custom whenever anything went wrong on the Indian railways for the railway officials to charge it on the Government. For instance, in the course of this debate, Mr. Bidder laid most improperly, Mr. Rendel maintained, the loss consequent on the failure of his Punjâb bridges on the Government. Mr. Bruce did the same thing twice in connection with the Great Southern of India. Now, Mr. Rendel contended, that he had as much or more experience of Indian railways as any Engineer here, and he said that charges of this kind were to be ranked with the attacks sometimes made in this country on officers of the Board of Trade,

which he should think had now been heard of for the last time. In his experience he maintained that the fault of the Government officers in the main was at the first a too ready acceptance of the views of the Company's officers, followed possibly in some cases after the failures of the Company's officers by what was a too ready distrust of them, and that if ever the history of the relations of the Government to the Companies came to be written, the officers of the Government need not fear comparison with those of the Companies.

He would now proceed to make some remarks upon the narrow-gauge system as applied to the Scinde and Peshawur lines. He would not go into estimates, because he had already said all he had to say in the report to which his name was attached, and because the time they would take was more than he could afford, except as a matter of professional duty; and because, as he also declined to consider the proposal to lay a 40-lbs. rail on the broad gauge anywhere, but specially on these lines, as a serious proposal, there was no necessity from his point of view for him to do so. If the military question was to decide the nature of the construction of these lines, it was folly to talk of retaining all the features of the broad gauge, except the essential features of the powerful rail; and no one, he supposed, was prepared to maintain that those lines could be built with a 60-lbs. rail or a 68-lbs. rail as cheaply as they could be built with a narrow gauge and a 40-lbs. rail.

It was supposed, he believed, that he was one of those who had urged the adoption of the narrow gauge on the Scinde and Peshawur lines. He had given no grounds for this opinion. In searching through the Report on the comparative cost of these lines on the broad and narrow gauge, signed by Colonel Strachey, Colonel Dickens, and Mr. Rendel, no such expression of opinion on the subject would be found. They were asked to give estimates for each gauge, they were not asked to give opinions as to which should be adopted; and accordingly they gave estimates and did not give opinions; and Mr. Fowler, in expressing an opinion, went, as Mr. Rendel told him at the time, beyond his instructions.

Now, when Mr. Rendel was engaged on that Report, he felt perfectly satisfied that for all commercial purposes any gauge would be sufficient for the Scinde and Peshawur lines, but he did not feel satisfied that there might not be political reasons which might make it desirable to construct them as first-class, heavy-railed, broad-gauge lines. If he had any doubt on the subject at the present moment he should, as a matter of loyalty to his employers, hold his tongue

on the subject; but he was convinced by the discussions which had lately taken place that the political question was not one which should govern the construction of these lines, and he was satisfied that the man who followed Lord Lawrence in this matter followed a safe and sure guide.

What was the principle of these particular railways as now laid out? It was this. Mr. Rendel assumed that the lines from Kurrachee to Kotree, and from Mooltan to Lahore, would be altered to the narrow gauge. There would then be a great trunk line resting on what was said to be a first-class harbour in the Indian Ocean, and running through the heart of the country to Peshawur, or further, a length of at least 1,200 miles, and throwing out branches on either side as circumstances might warrant. This would give a length of line ultimately exceeding the length of all the Irish railways, and traversing a district twice or thrice the area of Ireland. And it would be complete in itself. The natural division of the traffic of Upper India, between the Indus and the Gangetic valleys, would certainly be as high as Lahore, where the two gauges would meet, because, although the distance from Lahore to Calcutta would be greater than the distance from Lahore to Kurrachee, yet, owing to the lower rate at which the East Indian railway was and always would be worked, goods would be carried at least as cheaply—he might safely say much more cheaply—from Lahore to Calcutta as from Lahore to Kurrachee, and there was no reason to suppose that freights from Kurrachee would be less than freights from Calcutta; indeed there was every reason to suppose they would be higher.

As to the sufficiency of the mètre gauge, or even of a 2 ft. 9 in. gauge for the Indus valley, this must be considered—the Indus was at least as easily navigable as the Ganges. The East Indian railway, in order to compete with the Ganges, had reduced its rates for grain and seeds, which formed some 60 per cent. of its goods traffic, to little more than $\frac{5}{8}$ths of a penny per ton per mile, and even at that rate the river seemed to beat the railway. The river, in fact, could carry goods at little more than a farthing per ton per mile, taking the distance between the points of transport as the crow flies. How was the Scinde railway, which expended five times as much in mere working expenses, to compete with the Indus? He did not believe that, except in special cases, the Indus Valley railway would ever carry any important percentage of the produce of the Indus valley. It would go, as it did now, by boat, and all that the railway would get would be a little cotton downwards, a few bales of piece goods, a little copper and

a few 'notions' upwards; and unless it reduced its present rates, he doubted if it would do as much as that.

The only part of these lines which would have any material traffic on them would be the piece on the Peshawur line between the salt-mines and Lahore, a distance of about 100 miles. Above Peshawur, a few stores, reliefs of troops, a few camel-loads of dried grapes, and the few bales of European goods which penetrated through Afghanistan, would comprise the whole. So little was it expected to be, that it was in contemplation to design some sort of a combined locomotive carriage and wagon to run, as occasion might require, between the Jhelum and Peshawur.

His remarks were drawing out to such a length that he should be glad to leave the subject here, but as the estimates to which his name was attached had been attacked on the three following minor points, he must defend them.

First—he was told by Mr. Harrison that no allowance was made for the maintenance of the third rail which it was proposed should be laid between Kurrachee and Kotree, and between Mooltan and Lahore. Now, the fact was, that it had never been proposed that the third rail should be laid. He, for one, never supposed so foolish a thing would be done. He did not know whether the company could compel the Government to do so, but he hoped it would not be so unwise. The right thing to do would be, of course, to alter the gauge at once. All that the Commission did was to make a supposition to meet, in what they thought its worst form, a certain case put to them, and he maintained that they went quite far enough in providing a sum sufficient to lay a third rail without taking into account the cost of maintaining it. At any rate, he contended that the error was unimportant, because the third rail should never be laid.

Second—Mr. Bidder complained that they had not provided for the cost of absorbing the Scinde rolling-stock into some other broad-gauge system. He said that it would have to be taken up the river in boats, at a cost of £50 per wagon, and then be disposed of at a heavy loss. As to transporting it, Mr. Rendel should have thought there would have been no difficulty in taking it up country on the narrow-gauge line, either on narrow-gauge platform wagons, taking off the wheels, or by placing it on temporary narrow-gauge wheels and axles. As to loss in absorption by other lines, that, at the worst, was a mere matter of account. So far as the Government was concerned, it would be money out of one pocket and into the other, and therefore there was no need to make any provision for it in the estimate.

Third—The Commission was twitted—not by Mr. Bidder, who, Mr. Rendel strongly suspected, knew better, but—by Mr. Lee Smith and by Mr. Andrew, with not having provided for the laying a third rail on the whole of the sidings belonging to the Scinde railway.

What was the case? Why, the Scinde railway, which was only 106 miles long, and had a goods traffic equal, on the average, to about 30 loaded wagons per diem, had no less than 60 miles of sidings. The East Indian, with four times the traffic, had only one-third this proportion of sidings, and had certainly more than it wanted. The fact was, they did not know, until Mr. Lee Smith had told them, that the Scinde had all this siding. Had they known it, instead of providing for a third rail upon it, they should have recommended that some fifty miles of it should be taken up and be turned into a hundred miles of third rail, and have reduced their estimate accordingly. Who was responsible for these sidings? The Government, he supposed, as usual. These sidings represented a sum of at least £300,000; which was just as much wasted as if the money were thrown into the sea. No wonder the Scinde railway—a single line, without a work of any importance from one end to the other—had cost £18,000 per mile. These useless sidings represented £3000 per mile at least.

One word more, as to the policy of the Government in laying the Peshawur line alongside the road. Mr. Lee Smith said this was a mistake. But what were the facts? The Peshawur road was crossed by three great rivers, having a united waterway of nearly three and a half miles, and these rivers were at present unbridged. Now the bridging of such rivers was, of course, a matter of very great expense, aggravated in this case by the difficulty of fixing their course, and the consequent large expenditure required for their abutments.

The Government wanted to bridge these rivers for the road; it wanted to bridge them for the rail; and, as a matter of economy, it wanted to kill both birds with one stone. To do this, the rail must be brought to the road. The same bridges could then be made to answer both purposes, and this was being done. That alone was a sufficient justification for the policy of the Government. It might be, for aught he knew, that the salt traffic might be better provided for on Mr. Lee Smith's plan; but, after all, the salt traffic would be no worse off than it was now. It was not of such importance as to deserve that a large scheme should be altered to suit it. So far as the river was concerned, and in all other respects, it would be much better provided for.

He would now proceed to make some remarks upon Indian traffic, and the effective capacity of Indian railways for traffic, with a view to showing that the narrow gauge would be equal to all probable demands upon it. All those who were acquainted with the expectations formed of Indian traffic when Indian railways were first projected must feel that those expectations had not been realised. Mr. Rendel remembered the time when it used to be said that the East Indian railway would require near Calcutta four lines of railway. It was now doubled to the extent of about one-third its length, and was doubled to a greater extent than was necessary. The London and North Western railway carried last half-year 20,661,096 passengers and 11,509,939 tons of goods. The East Indian railway, a line of very nearly the same length, carried in the first half of 1872, its best half-year, only 3,061,567 passengers and 720,280 tons of goods—barely 15 per cent. of the passengers and $6\frac{1}{2}$ per cent. of the goods carried by the London and North Western; and the East Indian had at least twice the goods traffic of any other Indian line, and twice the passenger traffic of most of them, in proportion to its mileage. If it were not for the fact that Indian passengers and goods were carried enormous distances as compared with traffic on English lines, no one of them would pay its working expenses. How came it that in a country so populous and so fruitful the traffic was so small?

It could not be said that the rates were in fault, certainly not on any of the lines in regard to passengers, for the native passengers, who formed about 98 per cent. of the whole, were carried at less than $\frac{3}{8}d.$ per mile; nor on the East Indian, and some of the other lines, could it be said in regard to goods. The average rate on the East Indian, for the last half-year of which the accounts were rendered, was barely $1\frac{1}{12}d.$ per ton per mile, and at present it must be barely 1*d.* per ton per mile. On the London and North Western he was told, on good authority, that the average for goods would be rather above than under 1*d.* per ton per mile, while the average for passengers must be considerably over 1*d.* per ton per mile.

Nor could it be said it was competition; they lost something, no doubt, by the river competition, but the river was no such competitor to the railway as the Midland and the Great Northern lines were to the London and North Western railway.

The truth was that people were too apt to think that because a country was populous, therefore it must afford a large railway traffic. Numbers alone were insufficient. A people must be rich

as well as numerous to give large employment to a railway, and a small rich population would give a larger traffic than a poor large one. The people of India were, it was true, very numerous, but they were very poor. Being very poor, they could not afford to travel much, consequently the passenger traffic was small; being very poor, they could not use imported goods in quantity, therefore there was little for a railway to bring; being numerous, they ate up the bulk of the produce of the soil, therefore there was little for a railway to take away. That, combined with the absence of minerals in any large quantities, was why Indian traffics were so small.

But if the traffic offering itself for transport was vastly less in India than in England, the effective capacity of an Indian railway was vastly larger than the effective capacity of the same railway would be in England. He laid stress on the word "effective." An East Indian passenger train carried as many passengers in one train as the London and North Western did in about four and a half trains, and as much goods in one train as the London and North Western did in about one train and a half. He assumed here that the average rates charged on the London and North Western were as before given. If he took the Bombay and Baroda line, he found a still better result as regarded passengers—a Bombay and Baroda train carrying as many passengers in one train as the London and North Western did in six trains. Using round numbers, of course. And there was no doubt that if the Indian lines were worked as they ought to be, an Indian train would carry at least seven times as many passengers, and nearly twice as heavy a load of goods, as an English train.

The difference was of course due to the absence of the first and second class passengers in any numbers, and also to the absence of competition and of the pressure under which English traffic generally was conducted—evils probably irremediable in England, but which were never likely to arise in India. He had been speaking, of course, of the Indian broad gauge. Taking the effective capacity of a narrow-gauge train with the ordinary narrow-gauge engines at half that of the broad—the number of trains that might be run being, of course, the same on the one as on the other—he was justified in saying that the effective capacity of a mètre gauge in India would be considerably greater than that of a 4 ft. 8½ in. gauge in England, and that therefore it might be safely assumed to be largely in excess of any demands which could be brought upon it. No one, he supposed, would dispute that a suitable rolling-stock might be devised for

the mètre gauge. If any one did so, Mr. Rendel advised him to run down to Lancaster, to see the specimens at present waiting there for shipment. The only vehicle about which Mr. Rendel had heard a question was the horse-box. Now the horse-box on the East Indian railway carried 6 horses, 3 abreast, on a carriage 20 ft. long and having a wheel base of 11 ft. The horses were placed with their heads pointing inwards towards a central transverse passage in which the groom was placed. He was told they traveled all the better for seeing each other. A similar arrangement could be made on the narrow gauge for 3 horses, with a compartment for grooms on a length of 18 ft. and a breadth of 6 ft. 6 in. In the cattle van there could be carried 6 of the small horses of the country on a length of 18 ft. Camels and elephants did not travel on the broad gauge, and therefore need not be considered for the narrow.

Lastly, as to break of gauge. What case has been made against it? For a long time they were told to ask Mr. Grierson. At last, Mr. Allport got up, and said that he found it very inconvenient at Gloucester, and that he charged the public twenty miles for it. At least, so Mr. Rendel had understood him. He should think, at that rate, the more breaks there were, the better Mr. Allport would be pleased. Then Captain Galton stated that a friend of his told him, that break of gauge damaged salt to the extent of 1*s.* per ton, which he said, taking the relative value of salt in England and in India, made the loss in India nearly 7*s.* per ton. Did Captain Galton believe this himself; or if he did so, did anybody else? What were the facts? The salt which Captain Galton referred to was rock salt, quarried in a certain district about 120 miles above Lahore. This salt came out, as Mr. Rendel was informed, in blocks, which were placed in bags. The bags were either placed in carts or on the backs of camels, and so were slowly brought down to Lahore. Now that part which went by camels had a break of gauge night and morning, so that, according to Captain Galton, it underwent a deterioration to the amount of, say 1*s.* per mile, or, for the whole journey to Lahore, 120*s.* per ton. The value of the salt at Lahore was, he believed, just about 25*s.* per ton more than at the salt-mines, that being the cost of transporting it 120 miles in the manner he had stated. There was, of course, little or no deterioration at all, even with cart and camel transport, much less would there be any with railway transport, even with a break of gauge; and generally all the classes of goods found on Indian railways were such as did not suffer by transhipment. If they did, they would never reach their destination in a saleable condition at all, for the tranship-

ments which Indian produce, or articles imported into India, underwent between the place of production and the place of consumption were numberless. There was no resemblance whatever between English traffic and Indian traffic, and unity of gauge was a refinement necessary enough in England, no doubt, but totally unimportant to India. The only evil of break of gauge in India would be the expense of transhipment. Retardation was a matter of little moment, and indeed would be rarely increased under the leisurely system in which Indian traffic was conducted.

As to the cost of transhipment, an exact estimate could be arrived at. The East Indian Railway Company contracted for the transfer of goods between carts and the railway wagons at its different stations at 6 rupees per 1,000 maunds, which was equal to about 3½*d.* per ton. There was no reason why transhipment from railway wagon to railway wagon should cost as much. Nay, they knew that in the one instance, where the railway actually had in practice the break of gauge at the junction of the Nulhattie narrow-gauge line with the main line, the contract price for transhipment was 1 pie per maund, or just 3*d.* per ton. Now on the London and North Western railway the average sum paid by a ton of goods for transport was about 4*s.* a ton; 3*d.* on that amount would, of course, be a material item, and therefore break of gauge at that rate, as a mere question of money, would be serious in England. But the average sum paid per ton on the East Indian line, owing to the long distances traveled by goods on that line, was as much as 28*s.* per ton. On the Great Indian Peninsula railway it was as much as 43*s.* per ton, and 3*d.* on 28*s.* or 43*s.* was a trifle; and there was no doubt that the great bulk of the goods subjected to break of gauge would be goods going long distances, and paying, probably, from £2 per ton to £5 per ton for freight. A very large proportion of the goods carried on an English line, referring to the mineral traffic, was worth not more, before freight was added to it, than £1 per ton, even at the present time. Few things went into an Indian wagon worth less than £5 per ton. The cost therefore of transhipment would affect their value to a very small degree. Then as to the quantities transhipped. Taking, first, the Nulhattie line. The average daily goods traffic on that line amounted to about 25 tons; say that the whole was transhipped, what did it amount to? And many lines would, he expected, be made by the Government where no larger a traffic than that on the Nulhattie line could be anticipated; for, small as its traffic was, it appeared to pay 5 per cent. on its actual cost. Or, taking the present Great Southern of India

railway. The average goods traffic on that line was less than 100 tons, say 12 wagon-loads per day; and supposing the whole of that to be transhipped, where was the difficulty? After all, the question only came to this—that goods that would reach several stations by road would be concentrated by rail on one station. Why should every one be so anxious for feeder roads, and be so afraid of feeder railways, simply because they would be on a different gauge to the main line? So far as transhipment was concerned, both were under identical circumstances. Mr. Rendel had always thought this fear of a break of gauge in India a mere bugbear, and when, some years ago, the question was raised, how the transfer of traffic between the Great Indian Peninsula railway and the East Indian at Jubbulpore should be managed, and the officers of the East Indian line were, for the most part, in favour of the transhipment of goods as opposed to an interchange of stock, he strongly supported them, although he admitted that this junction was the one place in India where the evils of transhipment of goods might at some time be greater than the evils of an interchange of stock. But certainly, at the present moment, they were not so.

As to the political question, Mr. Rendel contended that it was the business of the Indian Government to decide matters of that sort in the interest of India, not in the interest of England. If England chose to consider Indian questions of this sort here, or to make them 'Imperial' as it was called, let the empire find the money, not wring it out of the Indian peasant.

But the financial and political part of the question was no business of his, else he might ask Mr. Andrew if he did not know that the great difficulty of Indian finance was how to raise a far less sum than this £1,600,000, which the Government was annually losing on Indian railways, and of which he seemed to think so little.

Here Mr. Rendel would conclude, did he not think it necessary to correct a misapprehension in regard to the prospects of Indian railways, to which the diagram, which Mr. Price Williams had given (Fig. 1, page 139), might give rise. That diagram showed the rate at which Indian railways and Indian traffic had progressed between 1861 and 1871, and Mr. Price Williams had drawn across it what he considered to be its curve of increment; the object being to prove that this loss of £1,600,000 a year would rapidly disappear. In the early part of the decade selected by Mr. Price Williams, railways had not penetrated into the country sufficiently deep to induce the goods traffic, coming down in carts from the interior, to finish their journey by rail. But as the decade went on, and

railways stretched well into the country, it paid the people to use them. The traffic consequently took a somewhat sudden leap. But since that leap was made, the increase had been very moderate. Indeed, the traffic of 1871 was less than the traffic of 1870, the falling off on the East Indian railway alone being over £300,000. The traffic of 1872 would show, he hoped, a trifling improvement; but that, he heard, was doubtful, and 1873 had opened with a heavy fall. Mr. Rendel feared the hopes of Indian railways lay rather in thrift than in increase of traffic. They did far too much work for the traffic they obtained; and they paid far too much for it; and his conviction was, that they were wasting between them half a million a year at least. Until they could knock this half million off their expenses, they could not afford to try what he believed to be their only hope as regarded revenue—a general reduction of rates.

Colonel YOLLAND, through the Secretary, and by permission of the President, said he thought there were grave doubts whether it was wise to have originally selected a 5 ft. 6 in. gauge for the railways in India. When that gauge was chosen there had been sufficient evidence of the capability of the 4 ft. 8½ in. gauge to prove, in his opinion, that it would be ample for the main trunk lines in India; and after 5,000 miles or 6,000 miles had been constructed on the 5 ft. 6 in. gauge, there should have been much more potent reasons, than any that he had as yet heard adduced, to justify the abrupt substitution of the 3 ft. 6 in. gauge, or of the mètre gauge.

As compared with the 4 ft. 8½ in. gauge, he believed the difference in the cost of construction on that gauge and on the mètre gauge had been greatly exaggerated. If the traffic was to be conducted at a moderate speed—say not exceeding 25 miles per hour—he believed that very sharp curves might be introduced, and safely worked on the 4 ft. 8½ in. gauge, with rolling-stock specially constructed for passing round such curves; and the same argument held good for the 5 ft. 6 in. gauge, although not quite to the same extent.

If, however, the main trunk lines had been constructed on the 3 ft. 6 in. gauge, or the mètre gauge, to the extent of 5,000 miles or 6,000 miles, and if it had been found out that a 2 ft. gauge would suffice for the wants of the country, and that a saving of a few millions would result from the change, he would still caution the authorities not to make that change as regarded the main trunk lines, as, although the money might be saved, it was quite possible that the country would be lost either to the enemy or to a disaffected population. A handful of Englishmen had already had to bear the brunt of great odds in India; and it was possible that a

state of affairs might occur again, when facility of transport from one end of the British possessions in India to the other, might be of the very highest importance.

He did not say that the narrow gauge might not be of great utility, in certain districts in India; but the break of gauge should not occur on main trunk lines; and, as a rule, he should prefer to see light rails made use of on the same gauge, rather than that the additional communication should be obtained by the introduction of another gauge. He believed that a great mistake was made in England on the part of the Government. When the report of the Gauge Commissioners was received, which recommended the broad gauge being confined to certain districts, the Government should have said:—"No; let no more extensions of the broad gauge take place—let us take the necessary measures for at once getting rid of it." He thought that would have been wise policy. In the same manner, he now hoped the Indian Government would be induced to retrace their steps, and to revert to the construction of the trunk lines on the same gauge on which so many miles had already been constructed.

Mr. A. S. Ormsby, through the Secretary, and by permission of the President, stated he considered that notwithstanding the Indian Government had obviously committed itself to an erroneous solution of the important question contained in the Paper, he hoped it would yet reconsider its decision. He was in favour of a gradual and permanent alteration of the Indian gauge to one of 3 ft. 6 in. It was now very generally admitted that a 5 ft. 6 in. gauge was too wide for India. The average load to be drawn, as stated by Mr. Rendel, was from 60 tons to 70 tons per train; but, taking it at even the maximum of 120 tons per train, he submitted there was a decided loss of power in setting a 45-ton engine and heavy rolling-stock to draw even the maximum load demanded by Indian railway traffic. If the annual waste of income, consequent upon the loss of power, were capitalised, it would be found to equal in a very few years any loss that might be occasioned by a change of gauge; while ever afterwards there would be a large annual diminution of working expenses, or increase of income, as the practical result of the change. He would, therefore, say to the Authorities:—"You admit you have committed an error in adopting the 5 ft. 6 in. gauge; do not, then, construct another mile of it; but adopt a 3 ft. 6 in. gauge, and gradually use up your present rolling-stock, and reduce the length of the broad gauge annually. In that way, you will bring the power into economical relations with the weight and the speed, and the earnings into a proper proportion to the

interest already guaranteed." He had been employed in the Punjâb for some years, and had traveled from Calcutta to Murree, and from there to Kurrachee, so that his views were the result of Indian experience.

Mr. W. P. ANDREW, in explanation, and by permission of the Chairman, said that, having been so pointedly alluded to by Mr. Rendel, it was a matter of common justice that he should be permitted to say a few words. He had never previously heard so many mistakes and so many errors in any essay—for it had not the excuse of being a speech. What was written ought to be accurate. Mr. Rendel had asked him how he would suggest that the Government of India should provide £1,600,000 for the deficit occurring from the railways now in operation. He would say the answer was very easy and distinct. Complete the Indus Valley line; connect the Punjâb line with the Scinde railway; and let the Government do, what they ought to have done years before railways were thought of—make roads. How could railways pay in a vast country, however fertile it might be, if roads were not made to the stations? And if railways in India did not pay as large dividends as those who, like himself, had been connected with them for a quarter of a century, anticipated, it was not the fault of those who constructed the lines in co-operation with the Government, but that the Government had not performed, and was not performing, its duty to India, in not having paid sufficient attention to the construction of common roads. As to the allusions to his friend Mr. Bidder—who he regretted was not present on this occasion to answer those strictures as to the bridges, which he could do so much better than Mr. Andrew could do—he would only say he was quite certain that Mr. Bidder never supposed for one moment that the Government Engineers were to give him any assistance in the construction of railway bridges. It was not in their province to have done so. Mr. Andrew would like to know what military Engineers in India knew about railway bridges? Who ever for a moment imagined that they could give advice on the subject? All he could say was, speaking to the best of his recollection, on two occasions the Government Engineers altered the sites of the bridges in the Punjâb, to the great detriment and expense of the Company; and more than that, as had been alluded to by Mr. Bidder, the Government prevented the company when giving the contract to Messrs. Brassey and Co. from arranging for three years' maintenance, after construction. The result was that, in the first year after the opening of the Delhi line, some of the bridges over the large rivers failed, and the Company was

saddled with the expense instead of the contractors. As to the other matters, about the sidings on the Scinde line, and as to the Scinde railway competing with the river Indus, he had never heard anything so extraordinary. The Scinde railway was never meant to compete with the river Indus. The object of it was to cut off the traffic of the delta of the Indus; and he believed, ever since the Scinde line had been opened, the traffic of the Indus had been stopped upon the delta, and the railway had carried the traffic from the top of the delta down to Kurrachee. It was to avoid the delays, the dangers, and the losses of the navigation of the delta. As to comparing the Indus navigation with that of the Ganges, he was surprised. The Ganges navigation was greatly superior to that of the Indus. It was not necessary for him to follow further what had been read by Mr. Rendel. He considered the statements that gentleman had made, however valuable as the results of his personal experience, had been answered in anticipation; but possibly those babes in the profession, Messrs. Harrison, Bidder, and Hawkshaw, would have been instructed had they been present. All he would say was, the break of gauge in the Indus Valley system was a matter of imperial importance. He thought the opinion was unanimous that, whatever gauge might be ultimately adopted in India, no alteration ought to be made in the system of the valley of the Indus. Let the Government, if it so pleased them, introduce the mètre gauge on subsidiary lines, but do not let them introduce a break of gauge on the system he had planned and advocated for so many years, a measure which could not fail to produce disappointment to the Government, and disaster to the interests he represented.

Mr. W. B. Lewis said, that he wished to refer to three points raised during the discussion, and to illustrate what he had to say, by information obtained by the Government of Victoria; but before doing so, he must express a hope that they might yet be informed upon whose advice this important step of the change of gauge in India had been taken? Hitherto it had been supposed that the reports, to which frequent allusion had been made, had something to do with the resolution, but now they were told that those reports were written subsequently to the decision, and that with regard to the Indus Valley and Peshawur lines, three of the Commissioners had purposely abstained from expressing an opinion, while the fourth had reported adversely to the course which had been followed. It appeared to him that the issue was narrowed to the question of estimate, but throughout the document which Mr. Rendel had read, it was assumed that by

adopting the narrow gauge there was to be an enormous saving gained. If that element was taken away, all he had urged became of very little value. It was also somewhat strange that reference should be made to traffic as it actually was, and as it had been, and that no reference should be made to the traffic as it was likely to be. In the colony of Victoria the question had been debated very keenly, and had been the subject of more than one Parliamentary inquiry. In the evidence given at the bar of the Upper House by Mr. Higinbotham, M. Inst. C.E., the Engineer-in-Chief of the Government railways, Mr. Lewis found, with respect to 220 miles of line, which the legislature had sanctioned, plans and estimates had been prepared showing the difference of cost between a light railway on the standard gauge of 5 ft. 3 in. with 50-lbs. rails, suitable for the traffic of the district, and capable of carrying the existing rolling-stock, except the engines, and a narrow gauge of 3 ft. 6 in., and the difference did not exceed £77,000. That was at the rate of £350 per mile. Those 220 miles would touch existing railways at three places; and the traffic-manager being asked for an estimate of the cost of transferring traffic at those points, gave £3,900 as the cost. That sum, capitalised at 5 per cent., gave £78,000, which at once swept away the whole of the saving. In addition, it was pointed out that not only the cost of transferring the goods would have to be met, but that there must be special stations where the trains of each gauge could come alongside the same platform; and those were estimated at £6,000 each, or a total of £18,000; and further, that those lines being worked alone, and not being suitable for the rolling-stock on the existing lines, it was necessary to add to the estimate, for rolling-stock, say, one-third. The assumed value of the rolling-stock was £500 per mile; one-third of which would be £166 per mile; but, to make himself safe, the Engineer-in-Chief took only £100 per mile: that was equal to £22,000. The account then stood thus:—

	£
Cost of transferring traffic capitalised . .	78,000
Cost of special stations	18,000
Additional cost of rolling-stock . . .	22,000
Total .	£118,000

Against this there was the saving of £77,000 for the narrow gauge, leaving a balance in favour of the existing gauge of £41,000. Pending the decision of the Government, tenders were called for, based on both gauges for two lengths of about 14 miles each, the rails to be provided by the Government; and it was

found the saving in one case was £181 per mile, and in the other £150 per mile. If they substituted the higher of these two figures for the £350 taken in the foregoing calculation, they found the balance in favour of uniformity of gauge was increased from £41,000 to £78,000. That was an example of a not very short length of line where the expenses contingent on a change of gauge doubled the saving to be effected by a reduction of gauge. Those figures were arrived at by fair estimates, and confirmed by actual tenders for the work; and it seemed to him, if they only got a saving of £150 per mile or £180 per mile, then all the arguments of Mr. Rendel and of the Author fell to the ground.

The Author, arguing upon averages, assumed an average saving which, when multiplied by many miles of railway, gave so large a total that, if maintained, it would become very important. The fallacy of this mode of reasoning was pointed out by Captain Tyler. As an illustration of this, Mr. Lewis would refer to information given in Mr. Carl Pihl's valuable report to the Agent-General of Victoria. In that report there was given the cost of all the railways in Norway—broad gauge and narrow gauge. The cheapest railway in Norway cost £2,765 per mile, and was constructed on the 3 ft. 6 in. gauge; while the dearest line cost £6,884 per mile, and was also on the 3 ft. 6 in. gauge. What was there called the broad gauge, or 4 ft. 8½ in. gauge, cost £5,812 per mile. It appeared that in the cost of the narrow-gauge lines of Norway there had been the enormous difference of £4,119 per mile, or more than 150 per cent. In the face of such figures as these it was absurd to look at such a country as India and to talk of an average cost that could be multiplied by ten thousand.

With reference to the challenge which had been made to any one to "question with a show of reason" that if the broad gauge had been adhered to in India, the rails would not have been lighter than 60 lbs. to the yard, and the general characteristics of the lines and stocks would have remained the same, he would mention that in Victoria, when the Government determined to make railways into the sparsely populated districts, their Engineer supplied estimates for them on the standard gauge of 5 ft. 3 in., constructed lightly, and at a very reasonable sum per mile. Now it seemed to him that what a responsible engineer in Victoria did, a responsible engineer in India could be found also to do. In Victoria, as in Great Britain, the advocates of the narrow gauge obtained a great deal of popular sympathy. The Legislative Assembly passed, with a good deal of enthusiasm, a Bill for railways on the 3 ft. 6 in. gauge. When the Bill went to the Upper House it was

subjected to careful inquiry at the bar of the House, and the result was, that the question of gauge was referred back to the Government for further information. The Agent-General was requested to procure reports from the most eminent engineers in England, America, and Norway. All the reports could not be procured in time, but those from Captain Tyler, Mr. Carl Pihl, Mr. Harrison, and Mr. Woods were received in time to be taken into consideration, and the result was that the Government decided to make light railways, as recommended by their own Engineer, on the old gauge; and the same Assembly which had voted for the narrow gauge rescinded that vote by a majority of four to one. He could not help thinking, if the question had been as fully ventilated with regard to India as it had been in Victoria, they would have seen a different result, and at all events they would not now be asking upon whose advice this serious and, as he believed, unfortunate step had been taken.

Mr. G. ALLAN read, from a voluminous manuscript, the following remarks. None of the narrow-gauge lines of India being as yet completed, the Meeting was necessarily without information as to the actual cost of their construction and working; and it was chiefly from the experience of other countries that facts could be obtained on which to form an opinion as to the relative advantages of the broad-gauge systems and of the narrow-gauge systems. He proposed, therefore, very briefly to lay before the Institution some opinions of engineers based upon the actual construction and working of narrow-gauge railways in the United States, and particularly of the representative narrow-gauge line of that country, the Denver and Rio Grande railway, the success of which had been so decided, that its gauge of 3 ft. had not only been accepted as the standard narrow gauge of the United States, but so vast an impetus had it given to railway enterprise in that country, that the number of narrow-gauge roads at present working, constructing, surveyed, and projected, represented a total of about 15,000 miles.

The Denver and Rio Grande railway had Denver, the chief town of the territory of Colorado, for its northern terminus, and traversed in a southerly direction the great rocky or mountain plateau of the continent, running along the valleys of the watercourses for a distance of 850 miles to El Paso, on the southern borders of New Mexico. The two territories of Colorado and New Mexico, through which the line passed, had very varied resources, and were together equal in area to four times the area of England and Wales; and although Colorado had but a very sparse population, New Mexico contained more inhabitants than any state or terri-

tory west of Kansas, except California; whilst Mexico, the adjoining country, had a population of nine millions. The line would eventually be extended to the city of Mexico, and would form a great north and south trunk road of 1,850 miles in length between the centres of both countries.

The first section, of 76 miles, from Denver was opened for traffic 15 months ago: 120 miles had been in operation for 8 months, and 158 miles for 4 months. It had been visited by many of the leading railway engineers of the United States, and its capacity for passenger and general business was admitted; whilst its reduced cost for construction and equipment had been to them no less surprising. For purposes of comparison with this narrow-gauge road, the Kansas Pacific line of 4 ft. 8½ in. had been taken, because it was built by the same engineers, and partly by the same contractor, and passed through a similar but somewhat less difficult country. The average cost of the Kansas Pacific for construction and equipment was 24,500 dollars per mile against 16,000 dollars per mile for the narrow gauge, representing a difference of 50 per cent. in favour of the narrow gauge. The rails of the broad-gauge line were 56 lbs. to the yard, and those of the narrow gauge 30 lbs. to the yard; but he should state that the cost of transport for the light rails was so enormous that their price on the spot averaged £18 per ton, their cost in England having been only £7 12*s*. 6*d*.

On this subject of cost, he could not do better than state the conclusions arrived at by the American Convention of Railway Engineers last year at St. Louis. It was composed of about fifty railway Engineers, Mr. E. Wragge, M. Inst. C.E., being one of its vice-presidents. It was at that convention that the gauge of 3 ft. was accepted as the standard for narrow-gauge lines, and compared with the broad gauge, the Convention, through its Committee, felt justified in coming to the following conclusions on the question of cost:—

1st. "That in very rough mountainous countries, where it was not necessary to run fast or time trains, the cost of construction of a 3 ft. gauge road would not be over one-fifth of such roads as the Erie, Pennsylvania Central, and Baltimore and Ohio; and that the capacity of the cheap road could at any time be increased by capital, so as to do all the business for all time to come; thereby saving a large amount in first cost, and interest on the same, which was the strongest possible recommendation for capital to invest in narrow-gauge cheap roads, rather than in the expensive broad gauge."

2nd. "That in the broken, rolling country, where most of our roads are constructed, the saving will be about as 1 to 2, namely, that the narrow gauge will cost about one-half as much as the present broad gauges have cost."

3rd. "That in the slightly undulating prairie, or plain country, the cost of construction of a first-class narrow-gauge passenger road, with the equipment suitable for a large freight as well as passenger business, will not exceed three-fifths of what a broad gauge would cost, with what is now called first-class equipment and road-bed; and that the real comforts and safety of the narrow-gauge are fully equal to those on the three great government broad-gauge roads—the Union Pacific, Kansas Pacific, and the Central Pacific."

Mr. Allan considered that these conclusions deserved great attention, as many of the engineers represented chartered narrow-gauge lines in operation or under construction, and were besides men of great experience in railway engineering.

He would hand in a few additional memoranda in respect to the Denver and Rio Grande railroad, which might be useful for reference.[1] It might be worthy of notice that the covered wagons in use on that line would carry about 11 tons of Indian full-pressed cotton in bales. As regarded the general efficiency of the rolling-stock, the Convention reported as follows:—"The Denver and Rio Grande are doing a general freight and passenger business, and are carrying live stock, wool, lumber, and, in fact, every class of freight; and their officers give it as their unreserved opinion, founded upon actual experience, and which is concurred in by connecting broad-gauge roads, that they gain in every case where the size of the car comes in question, and that in no case is the extra room of the broad-gauge car equal to the loss in dead weight."

He thought that these facts were sufficient to prove the capacity of narrow-gauge wagons to convey live stock, and they formed an equally satisfactory answer to the objection raised by Captain Galton against their complete efficiency for ambulance purposes. The German ambulance wagon of the latest type was 24½ ft. long, 8 ft. 3 in. wide, and 6 ft. 10 in. high, and contained accommodation for 10 men, with 138 cubic feet of capacity to each occupant. The corresponding Denver covered wagon was 22 ft. 1 in. long, 6 ft. wide, and 6 ft. high. It would accommodate 6 men, with a similar cubic capacity to each. Or, in other words, it would accommodate more men than was stated by Captain Galton to have been carried by the German broad-gauge stock throughout the late war.

---

[1] *Vide* Appendix IV.

So firm were the promoters of the Rio Grande line in their conviction of the success of their narrow-gauge line, that they undertook it without government, state, or local aid, and they had now the satisfaction of seeing it, even in its present uncompleted state, yielding a dividend of 8 per cent. upon its paid-up capital.

During the last seven years Mr. Allan had acquired an intimate personal knowledge of the requirements and resources of India, having reference not only to the nature of the country, but also to its commercial wants. He could safely affirm that, looking to the experience of the construction and working of narrow-gauge railways, the whole of the traffic carried on the present Indian systems could be, with the utmost facility, conveyed upon the new gauge adopted by the Government of India; and if the present type of construction —unfortunately extended over a distance of 5,000 miles in that country—was so greatly in excess of the demands upon it, how much more extravagant would it be to construct a secondary network of the same type. Those 5,000 miles of broad-gauge railway which had been laid out through the most populous and fertile districts of the country, enjoyed the privilege of conveying, on an average, some 675 tons of freight per mile of line per annum, or ½ ton freight per train mile; whilst, on the diminutive line of 2 ft. gauge, in North Wales, there was a freight traffic carried per annum of 10,000 tons per mile of line. The passenger and goods traffic upon the proposed extensions would be insignificant as compared with that commanded by the existing railways, and he would ask whether, if a line of 2 ft. gauge was capable of carrying in one direction only, as the Festiniog line did, fifteen times the average amount of traffic carried on the Indian lines, the mètre gauge adopted by the Indian Government would not be amply sufficient for all possible requirements? There were but three more points to be considered, and he would dispose of them in a few words. They were the question of speed, of break of gauge, and of fitness for military purposes.

With regard to the question of speed, he need only mention that speeds of 35 miles per hour were frequently attained on the Festiniog, Norwegian, and American narrow-gauge lines. Mr. Carl Pihl considered that 25 miles per hour was a suitable constant speed on a 35-lbs. rail; and that opinion was borne out by Colonel Greenwood, who lately informed Mr. Allan that the trains on the Denver and Rio Grande railway were frequently run at a much higher speed, and in fact that the ordinary running time of the trains over 120 miles, with 17 stoppages, was 8 hours; whilst the Scinde railway, with 7 stoppages, on its 5 ft. 6 in. gauge, took

8¾ hours to travel 105 miles. As to the break of gauge in its commercial aspect, he was confident that the allowance of *4d.* per ton, made by the Author, would be found ample. The experience of all other narrow-gauge lines was conclusive on that point. He should state, too, that a comparison of the consequences resulting to commerce between two of the main lines in England, had no reference whatever to the railways of a country which had only to carry half a ton per train mile, and with which to this day the native carriers by land and water successfully competed, not only for short, but for long distances. The inconveniences experienced in England had been dwelt upon with little consideration of the very different conditions existing in India. There the evils would, practically, be little felt at present, and if hereafter they should—from the increase of traffic and the multiplication of the points of contact of the two gauges—become serious, he ventured to predict that the broader gauge would succumb, as it had done in England, before its narrower and less costly rival. The fact was that by saddling so poor a country as India with an expensive system of railways, the British Government had terribly checked its progress; for even Mr. Andrew would not deny that had India possessed the 15,000 miles now to be given her, instead of the 5,000 miles it had taken a quarter of a century to provide her with, her social, and commercial, and national progress would have been greatly increased. Was there then such great reason to exult, with Mr. Andrew, on the blessings conferred upon the natives of India by charging them £18,000 per mile for their railways? Would railways be considered an inestimable boon to this country if they could not hold their own against the old road wagon?

As to the military part of the subject, it was admitted that the Scinde and Peshawur lines had great strategic importance, and that the plan adopted by the Government was, under the circumstances, the best. Having looked the question of cost fairly in the face, it had been decided to alter the present two broad-gauge sections, and thereby to establish an unbroken narrow-gauge system between Peshawur and its natural sea-base at Kurrachee over a distance of 1,092 miles. The distance of Calcutta from Lahore was over 1,500 miles; and they had, very properly, looked upon a break of gauge at Lahore as of the less importance, and more especially as the intervening country between Lahore and Peshawur was desert. Lahore, in an emergency, must of necessity be the great centre and depôt for all arms of the service, stores and munitions of war. A break of gauge, therefore, on the edge of a

desert country and at the end of a line 1,500 miles long, could not, for one moment, be set against the greater importance of a policy which had for its object the providing of a great system of railway communications, capable of doing all that could be required of them without being, as with the present system, a terrible burden to the country and a source of financial weakness. Mr. Allan thought it would be admitted, even by the most earnest opponents of the mètre gauge, that in adopting 5 ft. 6 in. as the standard gauge in India, a mistake had been made, and that a narrower and less expensive gauge would have sufficed for the wants of the country. If railway construction were now about to be commenced in India, he did not believe that any person present would advocate the adoption of the 5 ft. 6 in. gauge. But railway construction in India was only in its infancy; the 10,000 miles they were told were to be now proceeded with represented but a fraction of what would be ultimately required; and the Government of India, in recognising the mistake that had been made and resolving that it should not be perpetuated, was acting in the highest interest of the great country over which it ruled.

Mr. J. T. Wood said, that during the discussion much consideration had been given to the question, if, under the conditions of a load of 3½ tons on each wheel, a speed of 15 miles per hour, and a minimum goods traffic of 100,000 tons per annum over the greater portion of a line, there was any real economy in the construction and working of a railway on the mètre gauge, over the construction and working of a railway on the 5 ft. 6 in. gauge. Very few speakers, out of the many competent judges, had expressed a decided opinion of marked advantage in the mètre gauge, under those conditions. He suggested that the attempt to substitute the mètre gauge for the standard gauge, instead of rendering it subsidiary to it, was inconsistent with the spirit of the despatch from the Duke of Argyll of the 26th October, 1870, and was not the way to meet many of the present requirements of India as regarded cheap and remunerative transport.

It was usually considered a matter of course that the railway requirements of the military forces in India were of more importance than the railway requirements of the 240,000,000 persons who constituted the inhabitants of that country. He had no intention to go into the question of how or why England held India, but to confine himself to the provision of military transport, which was to take precedence of, and to be paid for by, the public. It had been stated that the existing carrying capacity of a single line, on the standard gauge, was the power of carrying 1,800

troops, fully equipped, 280 miles in 24 hours for many days together.[1] The capacity of the mètre gauge would, of course, be less in proportion. This capacity, however, was perfectly insignificant compared with that of the English railways, by means of which above 100,000 troops could be concentrated on any point within 24 hours. They had, however, the power of greatly increasing the carrying facilities in India in any particular district where the standard gauge existed, not simply by the power of concentrating existing rolling-stock, but by the power of using the concentrated rolling-stock by means of additional sidings, which, with an ample supply of labour, could always be laid down in a comparatively short time. A break of gauge would take away this power. What was the economical consideration that had induced the Government of India to give it up, for at least some years to come, as regarded the Punjâb lines? A contemplated saving of less than one halfpenny in the pound on the annual military expenditure in India, which exceeded fifteen millions sterling per annum, while 4 per cent. interest on the £530,000, which the Author estimated as the saving on the Punjâb lines, was £21,200.

But if Mr. Wood understood some of the previous speakers aright, it had been suggested that the power of carrying 11,000 troops, fully equipped, 280 miles in one week, would meet all the probable requirements of military emergencies in the Punjâb. If so, that result was within the capacity of an ordinary tramway, not even worked by steam power; and the Government would not be financially justified in making an expensive mètre-gauge military railway to be worked by locomotives, when its maximum requirements could be provided for at a much lower cost. The Wimbledon tramway, which had cost considerably under £1,000 per mile, with four cars only, each pair of cars being drawn by one horse, had carried 2,538 passengers about 1,200 yards in one day.

The despatch from the Duke of Argyll, which Mr. Wood had previously referred to, alluded to "lines mainly valuable for strategic purposes," and to "the great military lines of India being now complete." But if provision for military emergencies was to be omitted, and the ordinary military transport only to be considered, let them apply the Author's test of the use of those lines to the military, namely, the use actually made of them by the military. Statistics taken from the printed reports for the half-

[1] Vide Parliamentary Paper, 4th April, 1871, p. 39. "Report by Colonel [illegible], Colonel Dickens, and Mr. Rendel, 27th September, 1870."

year ending June last showed the conveyance of the military was as follows:—Scinde, under 6 per cent. of gross receipts; East Indian, Great India Peninsula, Madras, under 4 per cent. of gross receipts; Bombay and Baroda, under 2 per cent. of gross recceipts; and Eastern Bengal, under 1 per cent. of gross receipts. So that the ordinary military traffic did not amount to one twenty-fifth part of the general traffic of the country.

It was stated in the Paper that the transport of the utmost amount of traffic to be expected on any of the contemplated lines would certainly not be beyond the capacity of the mètre gauge; and that, on the contrary, that capacity would probably suffice for the traffic of the existing 5 ft. 6 in. gauge. Now what were the conditions which had to be provided for, and which were considered by Government essential to the maximum of success? 1, a charge of $\frac{1}{4}d$. per mile for passengers; 2, a charge of $\frac{1}{2}d$. per ton per mile for goods; 3, an uniformity of gauge for the subsidiary lines; and 4, a net return, on the average, on the outlay of not less than 4 per cent.

Clearly the arrangements to be made must depend on the amount of the traffic estimated in each particular case; and speed might be considered as only required for exceptional cases, and therefore be disregarded. The estimated traffic might not be sufficient to financially justify the making of any kind of road. They might have to begin with a tramway adapted to a load not exceeding half a ton per wheel, and to be worked by manual labour until the traffic justified the use of animal draught or steam power, and ultimately the conversion of the tramway into a 5 ft. 6 in.-gauge railway; but if they began by a locomotive railway in the first instance, when the estimated traffic would not justify it, they would inevitably impose an unnecessary burden on the tax-payers. It was essential that the cars and wagons on the mètre-gauge tramways should be so constructed and be made of such dimensions that several of them could be conveniently rolled into, and carried on, an ordinary wagon of the 5 ft. 6 in. gauge. This would go far to remedy the evils of the break of gauge as regarded economy in the supply of rolling-stock—by enabling an interchange of stock between different tramways to be made—and as regarded the transport of goods liable to damage by handling. The dimensions of the rolling-stock proposed, as given in Mr. Guildford Molesworth's report, were such, that only a single wagon could be placed on a standard-gauge wagon, and some of the stock, when so placed, would make the load too high for the standard dimensions of the Indian railways.

As regarded the capacity of the mètre gauge sufficing for the traffic of the existing 5 ft. 6 in. gauge, Mr. Wood had doubts as to the cotton traffic being carried on the mètre-gauge lines as economically as on the 5 ft. 6 in.-gauge lines. But he had no doubt that the mètre guage was not economically adapted to the traffic of the district he was more particularly interested in—the district of Eastern Bengal. He would state that, on the Eastern Bengal railway, they had the evils of break of gauge and keen water-competition to contend with. There was a break of gauge between the railway and the warehouses in the city, at one end of the line, and another break between the rail and the boats on the rivers, at the other end of the line. These breaks alone deprived the railway of an enormous amount of traffic. To obviate one break of gauge they had gone to a very heavy expense in bridging a river, and had not yet got the cost of crossing it down to the Author's 4*d.* per ton. The actual cost of transfer of goods between the railway wagon and a vessel alongside might work out at less than 4*d.* per ton, but the delay in the transfer of 1,000 tons was 2½ days, and the traders had found it economical to use sacks for grain and seeds, for the use of which they paid ¾*d.* per sack per trip. There were three kinds of traffic which they could not carry on a mètre-gauge line without having greatly to increase—probably to double—the number of trains, namely, jute, passengers, and fresh provisions. The distance was 152 miles. The goods trains were 11 hours, the passenger and provision trains 7¾ hours on the journey. Jute measured about 10 lbs. to the cubic foot; it was carried either in wooden wagons of 1,008 feet capacity, 18 ft. × 8 ft × 7 ft., or in iron wagons of 1,700 feet capacity. They carried last year 80,000 tons of jute during the 6 months of the season, almost the whole over 152 miles, but 250,000 cubic feet in a day was only a fair day's work. It would have required at least 400 trains more to have carried the same quantity by the mètre gauge, and as the traffic was all one way, they would have had the cost of 800 train miles run over every mile to set off against the interest of any saving that could have been effected by the mètre gauge; which latter, according to the Author's calculation, would not have exceeded £50 per mile. Next, as regarded passengers, they had 1,500,000 per annum to carry an average distance of not less than 35 miles, and they could not afford to go at a slow rate; this would necessitate additional trains for the mètre gauge. There had been instances in which their existing carriages had been blown over in a storm, so that the Canadian or any enlarged

carriage on the mètre gauge would not be safe. The fresh provision traffic was considerable, and required in a hot climate much space and peculiar arrangements.

Mr. Wood had alluded to the necessity of adapting the mètre-gauge tramway wagons to being transported by the 5 ft. 6 in.-gauge wagons. He anticipated that might be a solution of the difficulty of collecting and delivering much traffic from terminal stations in the large towns of India and from feeding tramways, and would greatly facilitate the transport by rail, in India, of many articles liable to pillage and injury in transport, such as salt, tea, opium, indigo, grain, and seeds. He laid no stress on the carriage of the dead weight, because he knew, by experience, that the haulage of a full train with a paying load of 300 tons required the consumption of $\frac{14}{65}$ more coal only, than the haulage of the same train empty.

He dissented from that portion of the Paper in which the Author argued that:—"On the reasonable supposition that the rates and fares of the guaranteed railways are fixed with a view to the production of the largest possible revenue, their gross earnings may be regarded as representing what the people of India, for whose benefit the railways were made, are willing to pay for such benefits; in other words, what, in their opinion, these benefits are worth. By being made to pay for the said benefits £1,660,000 over and above the amount represented by the gross earnings, they are plainly paying £1,660,000 more than the persons who use the railways, and who ought to be tolerably good judges of that particular point, do believe the said benefits to be worth."[1] If it was wished to take the test of the user of the lines, let the work done as measured by passenger mileage and ton mileage be taken—the mileage of the soldiers and military and government stores—the mileage of the letters and parcels transmitted by Government, a large portion of the 77,000,000 letters sent through the Indian post-office last year; but they should not take the amount that under a system of average rates and fares, instead of rates and fares applicable to each particular case, had been charged for railway transport in India. A railway in India, as regarded construction and working, cost as much or more than a similar railway in England; but in England they charged a third-class passenger one penny a mile, while in India they charged him only three-eighths of a penny. Near and round London it is now considered good policy, that the rate-payers should be under the obligation

[1] *Vide* ante, p. 7.

to make and repair the roads for the public good, and they had recently done away with all toll-bars. If they admitted a similar obligation, on the part of the Indian Government, to provide facilities for locomotion, the deficit would represent a payment, by the state, of an amount of 4 per cent. only, of the annual taxation, to obtain the enormous indirect benefit conferred by the railways on the community. No inconsiderable portion of the soreness attending the deficit might, however, be attributable to breaks of gauge of a different character to that of the break between the mètre gauge and the 5 ft. 6 in. gauge. There was the break of gauge between England and India; the break of gauge between the guarantors and the guaranteed; the break of gauge between the different departments of Government; and lastly, the *4d.* deducted by the English Chancellor of the Exchequer from the income of the shareholders, in pursuance of a narrow-gauge policy, from those who have constructed the railways in India; a sum in itself more than amply sufficient to pay the interest on the assumed extra cost of preserving the uniformity of gauge on the Punjâb lines for 'Imperial' purposes.

Mr. George Berkley said he ventured to make a few remarks on this important subject, chiefly because during the last thirty years he had opportunities of obtaining a somewhat special experience which should have enabled him to form an opinion upon it. Since the year 1849, his attention had been daily directed to the making and working of railways in India, and during that period he had visited India twice, and had traveled over the greater part of the existing lines of railway. Prior to that, in 1843, he had represented his great master, Mr. Robert Stephenson, Past-President Inst. C.E., in altering the gauge of the Eastern Counties railway from a width of 5 ft. 0½ in. to the ordinary 4 ft. 8½ in. gauge: and, subsequently, in attending daily the meetings and experiments of the Gauge Commissioners. Mr. Berkley was also engaged in all the battles of the gauges.

The statement which had been read by Mr. Rendel was chiefly remarkable for its omission of the main element under consideration, namely, the comparative cost of lines of the 5 ft. 6 in. gauge and of the 3 ft. 3 in., or mètre gauge, and on account of the statement that he had expressed no opinion on the introduction of a narrow gauge on the Punjâb railways. The question of uniformity or of non-uniformity of gauge not having been referred to Mr. Rendel, or the other commissioners who reported in 1870, the question naturally was, by whose advice were the narrow gauge and the breaks of gauge introduced? Certainly not by Mr. Moles-

worth, the Chief Engineer to Government in India, as that gentleman, in 1862, reported against the introduction of the narrow gauge into India, and in his report on the state railways he said that on his arrival in India he was informed, that "its adoption was a question which had been settled, and was not to be re-opened." A probable reason for the introduction of the narrow gauge appeared in General Strachey's statement, that the Government could not disconnect the two separate questions of the suppression of the companies and the change of gauge. Mr. Berkley could not understand what the one had to do with the other. It could scarcely have been imagined that such a reason could have been pleaded, if Mr. Rendel had not stated that "the simple reason for doing so was, that at the time the gauge was settled it was the intention of the Government of India to adopt for India the French system of weights and measures," which reason seemed to Mr. Berkley to be equally inappropriate.

The important feature of the Paper prepared by General Strachey, and which had been read by the Secretary, was the statement that the comparison which guided the Indian Government was that of two things which were not comparable, namely, of two railways, one of which had a capacity vastly superior to, as well as being more complete than the other. It was thus, Mr. Berkley believed, that a great deal of misconception had arisen. Lord Lawrence and Mr. Danvers had both made the same mistake. Lord Lawrence compared existing railways, which cost £12,000 per mile, with estimates for the narrow gauge purporting to cost £7,000 per mile. Every one must know that no such difference between the cost of lines of the two gauges, assuming them to be of equal capacity, could possibly exist. General Strachey and those gentlemen introduced a comparison of cost based on false data, which appeared to have been quite understood by the Author, who did not make a comparison between a railway with rails weighing 75 lbs. per yard to bear a load of 6 tons per wheel, and another line with rails weighing 40 lbs. per yard to bear a load of 3 tons per wheel, but who made the fair comparison between two railways constructed with light rails to carry equally light wheel-loads.

It had been stated by Mr. Rendel that railways of the 5 ft. 6 in. gauge, or even of the mètre gauge, were not justified in India, because, though the country was very populous, the people were very poor. It seemed to Mr. Berkley that Mr. Rendel and the Government had fallen into the error of taking simply the state of things as they actually existed. They had not considered the increase of wealth

and of commercial activity caused by the introduction of railways into a country. The idea of the Government on this point, Mr. Berkley ventured to say again, was based upon misconceptions.

It had been alleged by General Strachey that if the state railways had been made on the 5 ft. 6 in. gauge they would have been—not might have been—made with heavy rails. Now the Government having taken the construction of those lines into their own hands, and employing their own officers for the purpose, Mr. Berkley was quite at a loss to conceive why those officers should not make them of the same capacity as the proposed narrow-gauge lines. It had been pointed out to him as a proof that they would not, that when the Government decided to make the line to Hyderabad on the 5 ft. 6 in. gauge they adopted a heavier rail than they were going to adopt for the narrow gauge. Mr. Molesworth, however, had explained this by saying that the Government found there was a large traffic on the Hyderabad line, and they desired that it should be worked by the stock of, and in connection with, the Great Indian Peninsula railway. They also found another railway had a surplus of rails weighing 60 lbs. per yard, and other materials suitable for the purpose, and therefore they laid the line with the heavier rail. Mr. Berkley did not think that such an exceptional case could be taken as a proof that all state railways under state influence, though the gauge was 5 ft. 6 in., would be laid with heavy rails. General Strachey seemed to think they could not send their wagons over light railways, because, he said, they weighed 16 tons, and had only 4 wheels. Now Mr. Berkley was not aware of the existence of any such wagons, but if there should be one or two of that exceptional construction it would be advisable to put another pair of wheels under them. The Author also spoke of the difficulty, in case of emergency, of sending the locomotives of the existing railways over the light rails; therefore, he said, a large stock of surplus locomotives must be kept to meet those emergencies. That was answered by Mr. Bruce, who stated, very properly, that they could use heavier engines at a slower speed. When, however, they knew the speed on the state railways was to be only 15 miles per hour, Mr. Berkley did not hesitate to say they could use locomotives existing in the stock of the guaranteed lines, at that speed, in all cases of emergency.

He did not think that any one would dispute what was stated by Lord Lawrence—first, that they should be guided by past experience; and secondly, that economy—true economy—should be the object of them all. It was especially the engineer's business

to accomplish the object desired at the least cost. The Author started upon fair principles, and logically argued the case, but Mr. Berkley ventured to think his data and premises were incorrect. The question which that gentleman had asked was this:—What were the comparative estimates of the cost of construction and working, and the degree of present and future usefulness of lines of equal capacity on the 5 ft. 6 in. gauge and on the mètre gauge, introduced into India under the existing circumstances of railways in India? The Author argued, if Mr. Berkley understood rightly, that the existing lines had not been justified by the traffic that came upon them; that the people of India had been heavily taxed in consequence; that 3 ft. 3 in., or mètre-gauge lines, could be made to do all the work, and that they could be made at a saving of £1,000 per mile; and further, that the evil of break of gauge was represented by an estimate based on the small amount of present traffic at the Lahore station, and hence that it might be valued at a charge of *4d.* per ton. Mr. Molesworth stated, that some 2,800 miles of state railways were under construction, or were now intended to be made; and Mr. Berkley thought it better to deal with that which was probable, rather than with the mythical 10,000 miles, which represented nothing but a number of round figures which had been ingeniously introduced into the discussion, while the number of breaks of gauge consequent on their construction had not been referred to—the evil which would arise at Lahore being alone mentioned.

With respect to the present railways paying and being justified, he would say, in the first place, that the gross traffic did not represent by any means what the Indian people were willing to pay for the railways. They could not use the railways as much as they desired. He was glad to be supported in his views on this point by Mr. Rendel's statement. There were, in fact, very few bad weather roads; and therefore traffic could not be brought to the railway stations during the monsoon. The stock, establishment and capacity of railways had to be provided, to earn the dividend in some seven months of the year, instead of during twelve months. Roads were indeed much wanted in India for the benefit of the country, as well as for the advantage of the existing railways.

It had already been said that the construction of railways was justified by advantages not represented by dividend. There were certain parts of lines existing which did not and could not have been expected to pay any one, except the Government for strategic purposes; and over the whole of the lines the mails passed free,

with the exception of a small charge for the sorting carriages. The officers, soldiers, and the army followers traveled at much reduced fares, resulting in a very large saving to the Government. It would also be generally admitted that the effect of railways, made by Government, could not be argued, as proposed by the Author, simply upon the question of whether the dividend was 3 per cent. or more. When the effect of the introduction of railways into India was under consideration, the increased prosperity of the country, consequent thereon, should be taken into account. Now what had been the effect of railways upon the country already? Taking the year 1849, before the railways were commenced, the imports into the country—representing the comparative condition of the people—were about £8,300,000, and twenty years after that period they were £36,000,000. Taking the exports, representing the productiveness of the country, beginning at £16,000,000 in 1849, they rose to £53,000,000 in 1869. Was that no justification for the construction of the existing railways in India? Again, in the article of cotton the value exported, in 1849, was about £1,775,000, and in 1869, and since that date, the value exported had been upwards of £20,000,000. A number of other products had been much more largely cultivated. The export of jute had risen from about £68,000 to about £2,000,000; timber from £28,000 to £268,000; seeds from £71,000 to £2,000,000 in that twenty years. Did not that show that the growth of the wealth of the country had expanded with the construction of railways, which had given the required facilities for the carriage of the produce to the shipping ports?

In one of his valuable and interesting reports—written in 1860—Mr. Danvers stated that more than 1*d.* per pound was saved by the railways in the carriage of cotton: taking the quantity carried during late years, this saving had been from £2,500,000 per annum to £3,500,000 per annum; and in each of the years 1864-65-66, instead of £1,750,000, as in 1849, £35,750,000 worth of cotton was exported. The quantity, producing this enormous amount, could not have been carried to the shipping ports, if it had not been for the railways, and therefore it would not have been grown; and the difference in the value of that article alone in those three years exceeded 100 millions sterling, or more than the cost of all the railways put together.

The limited dividend now earned did not represent the required capacity of the existing railways. The traffic was bulky; the rates were not high, and the period, during which the dividend was earned, extended over only about two-thirds of the year. Rail-

ways must be capable of carrying at least the maximum existing traffic, which had amounted to about £132 per mile per week on a part of the Great Indian Peninsula railway, where the ruling gradient was 1 in 120, and to about £100 per mile per week on an incline of 1 in 40, of 14 miles in length. The power required to work this traffic, on such gradients, was fully as great as that which was necessary to work the traffic of the London end of the London and North Western railway over its gradient of 1 in 330.

It had been requisite to increase the power of the locomotives employed until they were as powerful as any in this country. The traffic which had existed could not be carried on the light 3 ft. $3\frac{3}{8}$ in.-gauge railway proposed by the Government. The traffic had increased, as had been explained by Mr. Price Williams, and it would certainly continue to increase.

The traffic on English railways, between the years 1849 and 1867, had increased in proportion to the increase of capital expenditure in the following ratios:—

Capital expended, 120 per cent.
Passenger traffic receipts, 240 per cent.
Goods traffic receipts, 400 per cent.

It was, therefore, not surprising to find, that the exports from Bombay, which were very largely carried by railway, had increased between 1849 to 1869 from £6,000,000 to £24,000,000.

In the absence of Mr. Fowler, he wished to make an observation on a misapprehension which he thought had arisen respecting that gentleman's report. The Author had based his calculation of cost, partly on figures found in Mr. Fowler's report, and, with the skill of an advocate, he had averaged those with other figures given by Mr. Hawkshaw. Mr. Hawkshaw had given an explanation of his figures, but Mr. Fowler was not there to explain his figures. Mr. Harrison and Mr. Bruce criticised, with fairness and truth, the basis of the estimate in Mr. Fowler's report. Now a careful reading of that report led Mr. Berkley to believe that the Author, as well as Mr. Harrison and Mr. Bruce, had been labouring under a misapprehension. Mr. Fowler stated distinctly, that the "dimensions, quantities, and prices" were assumed by him to be the same as those adopted by the other Commissioners—Messrs. Strachey, Dickens, and Rendel—for the purpose of comparing the cost of a 2 ft. 9 in. gauge, and a 3 ft. 3 in. gauge, the adoption of one, or the other of which, was the practical question referred to the Commissioners; and Mr. Fowler added, to make this clear, "that in carrying out the work I have advised the reconstructi[illegible]ch

detail." He guarded himself by those words from its being assumed that the dimensions, &c., were the bases on which he would calculate the difference of cost between the 5 ft. 6 in. gauge and the narrow gauge.

The subject of cost was all-important in this discussion; for, in the words of the Author, the only reason "for adopting a narrow gauge, was belief in its superior economy." Mr. Berkley had, therefore, taken the trouble, with the permission of Mr. Bruce, to examine that gentleman's estimates; and though he did not exactly agree with Mr. Bruce in the figures he arrived at, Mr. Berkley found that he had adopted a true method of comparison between the cost of lines made on the 5 ft. 6 in. gauge and on the mètre gauge. Mr. Bruce had to construct 216 miles of line on the mètre gauge. Every work was designed, and the quantities were ascertained. He designed them over again, making them sufficient for a line of equal capacity on the 5 ft. 6 in. gauge; the difference of the quantities were valued at the schedule rates of the contract, and he thus arrived at the correct figure representing the difference of cost. Why Mr. Berkley did not quite agree with Mr. Bruce's result was, because he did not think that works designed for a railway generally represented all the works that were required; therefore he thought there might be a percentage of contingencies, larger than was allowed by Mr. Bruce, which would tell upon the difference of the quantities, as well as upon the quantities themselves. Therefore Mr. Berkley preferred to put the extra cost at £250 per mile, instead of £200 per mile which Mr. Bruce had given. To check this further, he had, with the assistance of Mr. Manning—who had been for sixteen years in India, employed on the construction of the Great Indian Peninsula railway—taken out the quantities for upwards of 1,200 miles of the Great Indian Peninsula railway, and had applied to the difference of the quantities of earthwork, ballast, masonry in bridges and culverts, iron bridges, &c., the schedule rates at which such works had been executed, and he thus had arrived at the excess of cost of a 5 ft. 6 in. gauge line over one on the smaller gauge, in the country traversed by the 1,275 miles of the Great Indian Peninsula railway. The sleepers, which formed the most important item of excess, he took at the value per cubic foot at which they were delivered at Bombay, and charged them with 500 miles of railway carriage and 50 miles of land carriage. The result of that calculation was a difference of £400 per mile. Mr. Bruce was having his earthwork done for *4d.* per yard; the average price on the Great Indian Peninsula railway was *8d.* per yard, and other prices in Madras were lower than those ruling in the Bombay

presidency; but Mr. Berkley desired to err, if at all, on the side of over-estimating the excess of cost of the railways on the 5 ft. 6 in. gauge. He felt sure that the average difference of cost in India would not exceed £400 per mile. This difference of £400 per mile was in excess of that which they would have experienced; but assuming this amount, the account on the Punjâb railways stood thus:—773 miles at £400 = £309,200 = saving by mètre gauge; while the cost of laying the third rail and of extra rolling-stock would be £647,877: showing a balance in favour of the standard gauge of £338,677. To this must be added the cost of the tran-shipping station, the cost of working it, and the cost of maintaining the third rail, where laid. If therefore economy was to be regarded, the cheapest thing to do was to lay the 5 ft. 6 in. gauge, with light rails, on the Punjâb lines.

The saving which would be effected by making railways on the mètre gauge had not been stated by Mr. Rendel, but Mr. Molesworth had given his opinion, "that the saving in first cost of construction, between a narrow gauge line, and one on the standard gauge, was not large." Mr. Berkley had reported on the subject of the gauge of the Indore line, in which the commercial element was combined with the strategic element; which rendered it a case of, at least, as great importance as the railways in the Punjâb. It commenced by a junction with the Great Indian Peninsula railway at Khundwa, about 380 miles from Bombay, and formed part of a through route, from that city and shipping port, to Agra, Delhi, and the north-west of India. By the construction of the proposed state railways, passing Indore, on the mètre gauge, breaks of gauge would be established on that most important line of communication, at Delhi, at Agra, and at Khundwa, as well as at Lahore, and the prosperity of the district would be sacrificed; for while there was excellent iron ore and limestone, which had been worked on the state line, the coal necessary to utilise it was on the Great Indian Peninsula railway; in fact, the break of gauge at Khundwa would separate the coal, the iron, and the limestone districts, as well as important cities, districts, and military stations from their shipping port, and from the metropolis of western India. He believed there could not be any saving of cost equivalent to these serious disadvantages.

He did not propose to discuss, in any detail, the questions of the cost of maintenance and of working. Maintenance, he believed, would be practically the same on both gauges. The sidings on the narrow gauge must, necessarily, be longer, and therefore both their first cost and their maintenance would be greater on the narrow

gauge than on the standard gauge. The advantages in point of economy of working would, in his opinion, be on the side of the 5 ft. 6 in. gauge. On this subject he would quote Mr. Molesworth, who, in his report on the State railways, when speaking of the assumed superiority of the narrow gauge—in respect of dead load to load carried—said that it was a fallacy, and also stated—that which every one who knew India would confirm—that the traffic on the Indian railways was bulky, and that for bulky material the broad gauge was the more advantageous.

It had been argued, that a break of gauge in India was very different from a break of gauge in England; but whether in England or in India the evil would be in proportion to the amount of the traffic, and to the character of the traffic passing the point where the break was established. But the comparative inefficiency of the natives at the stations, and the pilfering and bribery going on, made it more serious in India, than in England, and it must be borne in mind, that it would affect the prosperity of the community quite as largely as it would affect the prosperity of the company.

Again, he found Mr. Molesworth had considered this subject, and had reported that the break of gauge was a "very serious evil," the amount of which was more than equivalent to 20 miles of carriage along the line, which he "understood was the estimate of traffic-managers." That was the expression of the Engineer-in-Chief of the State railways of India, with reference to ordinary traffic; but in speaking of the transferring of ordnance and ammunition, he said they, as yet, knew very little about it, and that it was necessary that a series of experiments should be made. Yet, before they had made the experiments—required to prove the efficiency of lines, necessary to ensure the safety of the empire—they were constructing these lines on a gauge the capacity of which was as yet unknown. Without going into details, which he had at hand, with reference to the Great Western railway, he might briefly mention that out of 893 miles of broad gauge—7 ft.—650 miles had been altered to the 4 ft. 8½ in. gauge; and he did not hesitate to prophesy that only a brief period would elapse before all the rest would be altered. It was difficult to arrive at the details of a Railway Company's accounts; but there had been votes taken which gave a pretty good clue to the outlay; and he did not hesitate to say that the cost of the adoption of an uniform gauge on the Great Western railway would amount to fully a million and a half sterling. Notwithstanding that enormous expenditure the company had, partly by getting rid of the evil of break of gauge, risen from a state of great adversity to the position of one of the most prosperous railways of England.

Of course this arose partly from a combination of other circumstances; but the increased prosperity was largely due to the establishment of uniformity of gauge. It had been urged by General Strachey, that the experience as to this English railway would not apply to India. Now was this true? If so, why had the Commissioners calculated on an expenditure of £327,177 on the Punjâb railways, to avoid the evils of break of gauge? and why did Messrs. Strachey, Dickens, and Rendel contemplate that it might be necessary to lay a third rail on the 5,000 miles of existing railway in India at an estimated cost of £5,000,000 sterling?

Mr. Berkley had entered on the consideration of this question with an earnest desire to see whether some compromise could not be introduced; because, though the Government might have made a mistake, they had bought materials for the state railways, and the question naturally arose, could they not use them somewhere? Must they sell them at a loss? If they did as the Eastern Counties Company had done, in days gone by, namely, make a present sacrifice to obtain an uniform gauge, they would, in his opinion, do that which was commercially wise, and which would be for the benefit of the country; but if this was too much to ask, perhaps the material purchased might be utilized on some of the proposed lines? Knowing India moderately well, and considering the fact that they had scarcely any roads to the present stations, that the land required irrigation, and that the harbours in India wanted docks, he ventured to suggest, that the Indian Government had yet a great deal to do, before entering upon the construction of 10,000 miles of railway; and that it would be wise to proceed with those works which would increase the productiveness of the land and utilize the existing railways, and to make only such new lines as would be feeders, or were strategically or commercially necessary, at the present time, in the cheapest way they could, by the adoption of inferior gradients and light rails on the standard gauge.

Colonel J. P. Kennedy, in an authorized communication through the Council, stated that he generally concurred in what had been said in regard to the evil effects of a break of gauge. Still he maintained that if there were no railways in India, and a gauge had to be chosen, the 3 ft. 3 in., or mètre, gauge was not the one which should be adopted. It could be incontrovertibly proved that such a narrow gauge was wholly inapplicable to the peculiar traffic of India. The proper principle was to make the width of the wagon-load proportionate to the width of the gauge. If, as proposed, the load was projected laterally beyond the base, or gauge of the

wagon, so as to carry the broad-gauge load on the narrow-gauge line, accidents would inevitably result from such a violation of the ordinary laws of equilibrium. He had carefully classified the goods traffic conveyed over the Bombay, Baroda and Central India railway, 312 miles in extent, during the years 1870 and 1871, according to the approximate specific gravity, per cube foot, compared with the bulk per ton of each kind of goods; [1] and he had arrived at the conclusion that such a classification was the only test by which the fitness of different railway gauges, or the proper distance between the rails of the wagon track for the conveyance of traffic, could possibly be established, as affecting the relation existing between the bulk and weight of the prevalent classes of product to be conveyed in any country. It showed that the fitting gauge for the conveyance of light products must be wide—while that for conveying heavy minerals might be narrow, and that the wide gauge suited both light and heavy traffic. It also proved that the 5 ft. 6 in. gauge, established for India in 1851, was the most suitable that could have been selected; whilst the 3 ft. 3 in. gauge, now sought to be established, would not merely introduce the inconvenience of a break of gauge, as in England, but, in addition, inflict a permanent injury upon the commerce of the country, by providing a wholly unsuitable means of transport for the products to be conveyed.

Mr. J. W. Grover, in an authorized communication through the Council, stated that the entire question of Indian gauge should be reconsidered. It was true that nearly 5,000 miles of railway had been constructed on the 5 ft. 6 in. gauge, but it was stated that 10,000 more miles had yet to be laid down, and if so, he would ask whether it would not be wiser to alter the gauge of the existing lines, rather than to perpetuate an error for the sake of preserving uniformity? At the first view, such a suggestion might appear startling, but he believed a little consideration would show, that changing the gauge was not so formidable an undertaking as persons might suppose. In the course of the last year he had to make several estimates for railways of considerable length and of various gauges, in the Austrian Empire—the lines running over a level country, such as the plains of Hungary. In considering the question of the gauge which should be adopted, he arrived at the conclusion that the saving of a mètre-gauge line, over one of 4 ft. 8½ in. gauge, was from 10 per cent. to 12 per cent., according to circumstances. He believed that amount could be saved in constructing a line on level ground, but

[1] *Vide* Appendix V.

when rough country had to be dealt with, the saving which would arise from adopting the narrow gauge would be much greater. Much depended upon the sharpness of the curves, and the manner in which the line could be made to accommodate itself to the mountain faces. In some places, particularly in the Austrian Alps, he found that he could get a very fair line on the narrow gauge at a moderate cost, with sharp curves, where it would be commercially impracticable to take a 4 ft. 8½ in. gauge line with curves of 10 chains radius. The real question appeared to resolve itself into this:—Was the 5 ft. 6 in. gauge in India made the most of, or was it not to a great extent wasted, and therefore superfluous? Which meant, could not the same-sized vehicles which were now placed upon it, be equally well carried upon a narrower gauge? In Canada, on the Toronto Grey and Bruce railway, vehicles having bodies 8 ft. 6 in. wide, precisely the same width as the Indian vehicles, ran with perfect security upon a gauge of 3 ft. 6 in. At Festiniog, there was a 2 ft. gauge, carrying trains safely round very sharp curves, having a very great super-elevation of the exterior rail. The vehicles had bodies of 5 ft. 6. in. width, and even 6 ft. width, or three times the gauge. In America, the Pullman cars were 11 ft. 3 in. wide on a 4 ft. 8½ in. gauge; and on some English railways, carriages 9 ft. 6 in. wide were used with perfect safety. Hence it was clear that the vehicles might be safely made more than twice the width of the gauge without any great reduction in the size of the wheels. Such being the case, it was manifest that the Indian vehicles should be made at least 11 ft. wide; but if this were done, they would become so bulky and ponderous as to be useless, and would give greater disproportion of dead weight to paying weight than they did at present. Hence, it appeared to him that the Indian gauge was a mistake, and the sooner it was altered the better. To effect such an alteration would, however, require time. Supposing it to be spread over from ten years or fifteen years, the Russians would not very likely be in a position to invade India before the alteration was effected. It was not possible for him, without special data, to give an estimate of the cost of the change, but he could not avoid commenting on Mr. Fowler's estimate of £52,500, or £500 a mile, for the conversion of the 105 miles from Kotree to Kurrachee from 5 ft. 6 in. to 3 ft. 6 in. He had received a letter from Mr. W. G. Owen, M. Inst. C.E., the Engineer of the Great Western railway, dated 27th February, 1873, in which he said, writing of the cost of converting the gauge of an ordinary railway simply laid on cross sleepers:—"I should think about £100 a mile single would be a good allowance, including such small

stations as you might have to deal with;" and Mr. F. Fox, M. Inst. C.E.—the Engineer of the Bristol and Exeter railway—also wrote to Mr. Grover, saying that he estimated £100 per mile for the alteration of a single line from the 7 ft. gauge to the 4 ft. 8½ in. gauge, not including the parts through the stations; the costs of altering the line through the stations he put at £160 per mile. The actual cost of altering one branch line laid on cross sleepers was only £71 per mile; and he summed up by saying that, "at the present prices, £160 to £180 a mile of single line would be a fair estimate for converting a 7 ft. to a 4 ft. 8½ in.-gauge line." The change of rolling-stock was of course a serious difficulty, and that of the engines was still more so; but the Bristol and Exeter Railway Company had been for some time having both engines and rolling-stock so constructed as to be convertible. The Chairman of that railway, in his last Report, observed that "the whole cost of converting the line would be £31,000," or, on 151 miles of double and single line, about £205 per mile. He also stated, that "at that moment they had 300 wagons, convertible at a cost of £3 to £5 each. They had three narrow-gauge engines, and eleven, either convertible or being constructed to be convertible, some of which would cost £50 each to convert, some £250 each; some of the shunting engines, £100 each."

If during the next ten years, or fifteen years, the rolling-stock and engines of the Indian lines were so built as to be convertible, or, indeed, if the broad gauge was transformed into the narrow gauge by degrees, the expense of the alteration might be rendered very small. For the sake of argument, he would assume that the conversion of the Indian single lines, on cross sleepers, would not exceed the cost of that of the double lines of the longitudinal system of the Bristol and Exeter railway, and that if £205 were enough for the latter, it should suffice for the former; always bearing in mind that the change must be spread over a period of years. If it were assumed that Mr. Bruce was correct, and that the saving effected by the adoption of the narrow gauge would be at the rate of £200 per mile only, there would be nearly enough saved out of every new mile of narrow-gauge line built in future to alter one mile of the 5 ft. 6 in. gauge. The Author assumed that 5 miles of 5 ft. 6 in. gauge could be altered for the saving effected by constructing one mile on the narrow gauge. If that estimate was correct, by the time 1,000 miles of new narrow-gauge line were built, the whole of the existing gauge might be altered. Mr. Grover's impression was, that the average saving of the 3 ft. 6 in.-gauge lines over those of the 5 ft. 6 in. gauge would be found to be

about £500 per mile for a single line in a country presenting a slight amount of topographical difficulty; and that the general cost of converting the Indian lines from the 5 ft. 6 in. gauge to the 3 ft. 6 in. gauge, spread over from ten years to fifteen years, would be—including allowance for stations, engines, and rolling-stock—from £300 per mile to £352 per mile. But, without acquaintance with India, it was not possible to give an estimate which could be received as universally applicable.

Mr. JOSEPH MITCHELL, in an authorized communication through the Council, stated some facts which had come under his observation, as Engineer to the Dingwall and Skye railway. That line extended from the main through-lines on the Moray Frith, on the east coast of Scotland, to Strome Ferry on the west coast, a distance of 53 miles. The object of the line was to connect the west coast and the islands of the Hebrides, with the east coast. But, as it passed through a thinly-peopled and pastoral district, it was necessary that the works should be constructed with the utmost economy. Mr. Fowler, who was a large landed proprietor in that district, was a Director, and Mr. Mitchell's late partner, Mr. Murdoch Paterson, was instructed to take in offers for a 3 ft. 6 in. gauge. The following data were furnished for his guidance:—"Gauge, 3 ft. 6 in. from centre to centre: rails, 45 lbs. per yard; chairs, none; rails to be fastened by keys, as in Germany and France; ballast, 15 in. deep: excavations, embankments, bridges, &c., to be reduced accordingly; sleepers, 7 ft. by 8 in. and 4 in., half covered, 3 ft. apart from centre to centre. When saving can be made, curves of ten chains radius to be adopted, and gradients of 1 in 50 to be adopted, wherever a saving can be made by the alteration. The weights to be calculated for bridges will be two-thirds per lineal foot of the calculations for the 4 ft. 8½ in. gauge. No dressed stone to be used unless absolutely necessary." A line of 4 ft. 8½ in. gauge was ultimately determined on, and it consisted of sleepers, chairs, and ballast of the ordinary size and strength for that gauge, with works of the most substantial construction, the rails 70 lbs. per yard, the whole capable of sustaining the Highland Company's heaviest engines, with curves, which were very few, of 15 chains radius. As economy was of the greatest consequence, Mr. Paterson drew up the specification and schedules with great care, advertised the works, and received tenders from ten different contractors. The lowest, from a most respectable firm, was—for the 3 ft. 6 in. gauge, £2,860 per mile, and for the 4 ft. 8½ in. gauge, £3,920 per mile, making a difference in cost of £1,060 per mile. The

Directors, after due deliberation, and considering that their goods traffic would be heavy trains of cattle, sheep, wool, and fish, preferred rather to encounter the extra expense of £1,060 per mile, and to adopt the 4 ft. 8½ in. gauge, than to be subjected to the inconvenience and annoyance of a break of gauge at the junction of the main through lines. The line had been completed, including land and every expense, at a trifle over £5,000 per mile, and had been opened for two years. He never heard a complaint or any regret that the 4 ft. 8½ in. gauge had been adopted.

Although a great advocate for the narrow gauge, the Duke of Sutherland, on his extension railway—through his own county to the extreme north at Wick and Thurso—84 miles in length, had felt it prudent to use the 4 ft. 8½ in. gauge, on the ground that it was an extension of the main through line, and that it was objectionable to have a break of gauge.

Colonel J. T. Smith, R.E., F.R.S., in an authorized communication through the Council, stated that the question of the relative amount of the working expenses on the different gauges had apparently been passed over by nearly all the speakers, possibly on account of its obscurity, and of the difficulty of procuring the necessary data for comparison. It appeared to him that the comparative working costs of the two lines were quite as important as their comparative first costs. The necessity of not burthening the Indian revenue had been urged; but it was not the first cost which burthened the revenue, —that would be borrowed in any case—but it was the interest of the first cost, added to the current expenses of working the lines, which was the real charge on the current revenue.

If the cost of the whole programme of the Indian Government were assumed to be £60,000,000, and the interest £3,000,000 per annum, the working expenses, when the lines were developed, might approximately be taken to be equal to the latter sum, and ought not to exceed it; the whole current outlay to be met by receipts being £6,000,000 per annum. But if it were the fact, that the working expenses of the proposed narrow-gauge lines were, by any possibility, double that of the standard-gauge lines, it was clear that the demand upon the current revenue would be exactly the same as if the railways cost £120,000,000, instead of £60,000,000: and in the same way in proportion to any other excess. Hence the working expenses were of fully as much importance as the cost of construction. They were, indeed, more so, if the interests of commerce, as well as those of the Government Treasury, were duly considered.

The difficulty of obtaining data for comparison, as to the working

expenses of the several gauges, arose out of the want of a sufficient number of examples of each kind, which would be, in all respects, under equal conditions. There were a number of standard-gauge railways, in Great Britain, which might be safely taken to be well made, maintained, and managed, and under equal conditions, as to the prices of materials and labour, but there were not an equal number of narrow-gauge railways to compare with them. The narrow-gauge lines of foreign countries, even if it were granted that they were equally well constructed and maintained, could not be used for purposes of comparison, nor could the working expenses of tramways, or hastily and cheaply built contractors' lines, be taken as a basis. The only example he was aware of was the Festiniog railway. That line was well constructed and maintained, and had been worked under similar circumstances to other British lines, in respect to the prices of materials and labour. There was ample information regarding it, and it was acknowledged and appealed to as a specimen of the system. He did not propose, however, to argue that the results shown by the Festiniog line, and which would be found unsatisfactory, fairly represented the necessary accompaniments of the narrow-gauge system. He should consider it unfair to erect a general principle upon a single instance, however unexceptionable it might be. All he wished to deduce from the information which that railway supplied was, that there was *primâ facie* evidence to show the probability of there being extra expense in working narrow-gauge lines; and that, considering the equal or even greater importance of that feature of the system, it was of great importance that it should be thoroughly investigated before a decision was arrived at.

Most of the facts connected with the working of the Festiniog line were given in Mr. Spooner's work entitled "Narrow-gauge Railways," published in 1871. First, in regard to fuel, at page 23, it was stated that the consumption up to that time had amounted to "a little over 50 lbs. per train mile, or about double that of an ordinary well-proportioned passenger-engine." Explanations were given to account for that apparent waste; but when all the circumstances of the case were considered, Colonel Smith thought it would be found that no allowance need be made. The consumption of 50 lbs. per train mile was 24 per cent. beyond that of the Madras railway during the first half of 1872, although that line had long and steep gradients. Its cost, also, which was at the rate of 4·96*d.* per train mile, was 59 per cent. beyond the average charge reported on twenty-four of the principal British lines.

In regard to working expenses, there had been an official state-

ment made in March, 1871, by Mr. Guilford L. Molesworth, M. Inst. C.E., now Consulting Engineer for State railways to the Government of India—after a careful analysis of the facts—that the working expenditure per train mile was "nearly double that of the average of English railways, and more than three times as much as that of some Irish railways, on which the rates of labour would probably more nearly resemble those of a remote Welsh district like Festiniog."

Another comparison was afforded in Mr. Spooner's work, page 39, wherein a statement was given of the expenses of working, per train mile, of four English lines and of three Indian lines, as well as of the Festiniog line. The last was stated to be 4·6*s.* per train mile; and the average of the four English lines was 2·773*s.* per train mile; the Festiniog line being thus nearly 66 per cent. in excess. Colonel Smith had made a similar calculation of the working expenses of six leading English lines for the first half-year of 1872, which gave a more unfavourable result. That was the more remarkable, as the Festiniog line was worked under some considerable advantages as compared with others. It was maintained in excellent working order, and the speed was limited to 12 miles per hour. Three-fourths of the gross traffic—namely, that for the downward journey to Port Madoc—was moved by the force of gravity; the remaining fourth, however, being subject to extra haulage, owing to the excess rise in the gradients. The freight was of an exceptionally compact kind, and the trains were completely filled.

Admitting that, on closer investigation, much of the apparent discrepancy between the working expenses of the Festiniog line and of the standard British lines might be accounted for, there nevertheless seemed to be strong presumptive ground for the belief that there was more or less inherent disadvantage in the system. An increase of only one-tenth in the working expenses of the railways constituting the programme of the Government of India would produce an equally onerous burthen upon the finances of the empire as an extra outlay of £6,000,000; which amount was probably more than the saving in first cost which the advocates of the narrow-gauge system would now lay claim to.

Were the discussion confined, as he thought it might be, to a comparison of the employment of vehicles of precisely the same dimensions, namely, those now proposed for the narrow gauge, and almost exactly the same weight, adapted to light rails, set in the one case at 5 ft. 6 in. apart, and in the other at 3 ft. 3⅜ in. apart, the conclusion arrived at would be, a slight saving in the first [illegible] of the narrower line, and an equal or greater saving in the

working expenses of the broader line, upon which the same-sized carriages would run more steadily, and there would be room for the employment of more effective and economical engines.

One of the strongest arguments in favour of the narrow-gauge system was, the 'handiness' of the stock and engines, and their suitability for a small traffic, such as was met with on first breaking ground in a new district. But as there was no real difficulty in constructing narrow-gauge stock to run upon rails 5 ft. 6 in. apart, it might perhaps meet the views of the Government of India, under the present circumstances, to lay down and equip the projected lines with light rails, 5 ft. 6 in. apart, and a permanent way able to bear the rolling-stock of the larger lines, together with light vehicles which would be able to traverse all the main lines. When the traffic of the district was so far developed as to require more accommodation, the light rails and vehicles would be pushed forward to form branches, and their place would be taken by rails and vehicles of larger dimensions.

It had been more than once stated, in the course of the discussion, that the existing guaranteed Indian lines had proved to be a commercial failure. He trusted that, before many years had passed, that would be found to be a premature decision. Railways in India had to create trade, as well as to minister to it, and they therefore required a long time for their due development. The lines, to which the statement applied, were only recently finished, and none of them were fully developed; nevertheless, one or two lines had already reached the return which was assumed as constituting success, and they had divided, with the Government, a surplus revenue.

A statement had been made, by one of the highest authorities, that during the last fifteen years an increase had taken place in the Indian revenues, in a great measure attributable to the railways, to the extent of £20,000,000 sterling per annum. If only a moiety of that annual gain was credited to them, it could hardly be considered an unsatisfactory return for the advances out of the Indian treasury, which, up to the present date, were reported to be in the aggregate less than £20,000,000 sterling.

Mr. William Dennis, by permission of the Council, and through the Secretary, stated, that he was constructing a railway in the West of England, on the original broad gauge of 7 ft.; and, having all the quantities and prices of the work in great detail before him, he had gone into a calculation of the saving which would have resulted, had the line been constructed on the narrow gauge of 4 ft. 8½ in.—the difference between these gauges being almost

identical with the difference between the mètre gauge and the 5 ft. 6 in. gauge. A summary of the results was given in the tabular statement on page 193.

It gave the comparative cost of a broad gauge (7 ft.) railway, and of a narrow gauge (4 ft. 8½ in.) railway, through a moderately easy country, permitting the use of curves of a minimum of 20 chains radius, both lines being built to sustain an equal rolling load. The quantities and prices were taken from working drawings and contract schedules. The length of the line was 8 miles. The works and way were for a single line.

As affecting the value of the comparison, it would be noticed that the railway was one of only average difficulty; traversing a fairly open country, where nothing would be gained by the employment of curves of less than 20 chains radius. In his calculations he had taken the same weight of rail, the same depth of ballast, and the same scantling of sleepers, reducing the length of the latter from 11 ft. to 9 ft. Under the circumstances, he found the saving which would have resulted from the use of the 4 ft. 8½ in. gauge amounted to £334 per mile, or about 5½ per cent. on the cost of the 7 ft. gauge.

Mr. Edward Woods, by permission of the Council, and through the Secretary, stated that he had no local acquaintance with India; but having been connected with railways, in many parts of the world, for nearly forty years, he was enabled to speak with confidence on the general questions under consideration, more especially as he had had much experience in the construction of railways of various gauges, and of the rolling-stock to correspond. The railways he referred to were of the gauges respectively of 4 ft. 8½ in., 5 ft. 6 in., 3 ft. 9 in., 3 ft. 6 in., 3 ft., and 2 ft. 6 in., besides some tramways of even smaller gauge.

In the commencement of the Paper the following passage occurred:—"Now that, *cæteris paribus*, a narrow-gauge railway must be cheaper than a broad-gauge railway, would, as an abstract proposition, seem to be also a self-evident one. It may indeed be objected, as it has been by a high authority, that the elements which determine the cost of a railway are the size and the weight of the vehicles to be used upon it, and that it is equally possible with the same gauge to use either broad or narrow, heavy or light vehicles; and doubtless it would be possible, by furnishing a narrow-gauge line with heavy rails and other constituents, and with broad vehicles, to cause the cost to exceed that of a broad gauge with light rails and narrow vehicles. Practically, however, the broad gauge is never adopted except when broad, heavy vehicles,

—	Broad Gauge.		Narrow Gauge.		Saving on Narrow Gauge.		Saving per Mile.	Percentage of Saving on Cost of Broad Gauge.	Remarks.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.			
	cub. yds.	£	cub. yds.	£	cub. yds.	£	£ s.		
Earthwork	183,900	8,429	171,730	7,871	12,170	558	69 15	6¾	Formation width. Broad gauge = 15 ft. cut^s. 17 ft. emb^t. Narrow " = 13 " " 15 " "
Bridges	No. 9	3,058	No. 9	2,928	..	130	16 5	4¼	8 of these bridges are of masonry. 1 masonry abutments, plate girder top.
Culverts	.. ..	1,411	..	1,333	..	78	9 15	5½	
Sleepers	No. 16,928	4,444	No. 16,928	3,245	..	1,199	129 14	27	Line and sidings, 9¼ miles in length. Broad-gauge sleepers, 11 ft. × 10 in. × 5 in. Narrow-gauge do., 9 ft. × 10 in. × 5 in.
Ballast	cub. yds. 36,432	3,643	cub. yds. 31,032	3,103	cub. yds. 5,400	540	58 14	14¾	
Land	acres. 60	12,000	acres. 57¾	11,550	acres. 2¼	450	50 0	3¾	The average price of the land purchased is about £200 per acre. A great portion was given; but for the sake of this comparison it is taken as if it had all been purchased at this rate.
Rails	tons. 1,030	8,755	tons. 1,030	8,755	..	..	..	..	71 lbs. rails (Vignoles), fish-jointed, and bolted to cross sleepers, 3 ft. apart, centre to centre.
Fastenings	.. ..	2,324	..	2,324	..	..	..	..	
Laying way	lin. yds. 16,192	809	lin. yds. 16,192	809	..	..	..	..	No saving on any of these items.
Fencing	29,040	2,277	29,040	2,277	..	..	..	..	
Level crossings	.. ..	514	..	514	..	..	..	..	
Drainage of cuttings	.. ..	250	..	250	..	..	..	..	
Electric telegraph	.. ..	224	..	224	..	..	..	..	
Stations	.. ..	5,000	..	5,000	..	..	..	..	
Maintenance and sundries	.. ..	862	..	862	..	..	..	..	
Total	.. ..	54,000	..	51,045	..	2,955	334 3	5½	

nor the narrow gauge, except when comparatively narrow and light vehicles, are intended to be used; and in any comparison of the two gauges this intention may always fairly be assumed."[1] Mr. Wood would premise that the preliminary propositions laid down by the Author were substantially without foundation in fact. It had been the duty of Mr. Woods, in certain cases, to construct narrow-gauge lines, which, from the nature of the traffic to be provided for, had necessarily been more costly than broad-gauge lines would have been.

From the observations made by Lord Lawrence, it would be assumed that he entertained the belief in the proposition laid down by the Author, a proposition accepted by all the speakers who had followed on the same side, namely, that the cost of lines might be computed to be in proportion to the width of gauge. Mr. Woods could not but believe that this fallacy had underlain the decision of the Indian Government to adopt the mètre gauge. He also considered that a mistake was originally made, by the Indian Government, in sanctioning the formation of lines equal, and even in some respects superior, in point of construction and equipment, to the first-class English railways. By the establishment of a wider gauge than was necessary, even in England, a very large and unnecessary outlay had been occasioned.

An entirely contrary policy had prevailed in respect to the railways of the United States and of the Spanish Republics of the South American continent. The railways in those countries had, for the most part, been made at much less than half the cost of the Indian lines. They were, nevertheless, well adapted to the requirements of the traffic, and their gauges varied from 4 ft. 8½ in. to 5 ft. 6 in. In the United States and in Peru the prevalent gauge was 4 ft. 8½ in., whilst in Chili and the Argentine Republic the standard gauge had been fixed at 5 ft. 6 in.

In the latter country he had lately constructed a line 247 miles in length of 5 ft. 6 in. gauge, with its sidings, stations, and rolling-stock, for little over £7,000 per mile, with rails of 62 lbs. per yard. Had the advisers of the mètre-gauge lines in India, and those who indulged themselves in the belief that there was necessarily, and intrinsically, an important difference in the cost, as between narrow-gauge lines and broad-gauge lines, taken the trouble to inform themselves of what had been going on, during the last twenty-five years, in other quarters of the world, they would

[1] *Vide* ante, p. 4.

scarcely have lent their sanction to the retrograde policy now commenced.

What had been done in regard to the maintenance of the standard gauge in the colony of Victoria had been fully explained by Mr. W. B. Lewis. Mr. Woods had been enabled to examine the documents and evidence bearing upon the proposed change of gauge in that colony, having been one of the Engineers who were called upon by the Right Hon. Mr. Childers to report on the subject, and he found, after careful investigation of the plans and sections of the proposed line, that the Government Engineers' estimate of the saving to be effected by the adoption of a 3 ft. 6 in. gauge in lieu of a 5 ft. 3 in. gauge, namely, £261 per mile, was in excess, as had been subsequently shown to be the case by the comparative tenders of the several contractors. That such must be the case, under all ordinary circumstances, appeared obvious, when it was considered how large was the proportion of constant and variable expenses; for amongst the former were to be classed the surveys, the preparation of plans and sections and specifications, the preliminary expenses, the compensations to be paid to landowners for severance, and as regarded the works, fencing, retaining walls of embankments, the wing walls of bridges, the fronts of culverts, level crossings, signals, telegraphs, and permanent way; for he held that, given the dimensions of the vehicles, and the weights they were required to carry, those being the elements which should determine the width of gauge and also, indeed, the width of the bridges and the tunnels, the cost of permanent way and ballast would be nearly the same on gauges of 3 ft. 3 in., 4 ft. 8½ in., or 5 ft. 6 in., whilst the variable elements incidental to the difference of gauge consisted of only a small slice of land, another of earthwork, and of culverts and under-bridges corresponding with that difference of width.

The attempt to reduce expenditure by changing the width of gauge in India, and by introducing breaks of gauge, was essentially a retrograde movement; for the object sought could be attained as easily, and with far less inconvenience, by returning to the practice of former years, when lines and rolling-stock in England were of light construction. Mr. Harrison had given the results of his experience on that head. Mr. Woods might also refer to his own experience on the Liverpool and Manchester railway, where during the first ten years of its existence a very large traffic was carried over rails of only 35 lbs. per yard by engines not weighing, on an average, more than 10 tons each. Those weights of rails and of rolling-stock were inferior to what were now proposed for the mètre-gauge lines of India.

The Author had based his justification of the mètre gauge solely on the supposed saving in first cost. He had omitted to take into account the additional cost in working, which such a change would involve; for it was clear that a much larger number of wagons, carriages, and engines would be required to transport a stated amount of traffic, giving rise to a corresponding increase in wear and tear of moving parts, such as wheels, axles, axle-boxes, and springs, and to much additional labour in handling, at the stations, and also the fact that the trains must be more numerous and the train-mileage proportionally increased.

In the course of this discussion it appeared to have been supposed by some of the speakers, that the alteration, by the Great Western Railway Company, of their broad-gauge (7 ft.) lines into narrow-gauge (4 ft. 8½ in.) lines, was to be received as conclusive proof of the superiority of the narrow-gauge over the broad gauge, and hence the inference that advantage would be gained by still further narrowing the gauge; but it was well known that this change had been made solely for the purpose of removing the pressing evils incidental to the breaks of gauge, so fully explained by Mr. Allport. The broad gauge had given way to the narrow gauge, because the extent of narrow-gauge lines was so greatly in excess over that of the broad-gauge lines; and because it would, in most cases, have been physically impossible, by reason of the insufficient widths of tunnels and bridges, to have converted the narrow-gauge lines into broad-gauge lines, even if otherwise desirable.

As regarded the evils incidental to breaks of gauge, he could confirm all that Mr. Allport had said. Since the break of gauge was first established at Gloucester, and afterwards came into play at other points where the two systems met, Mr. Woods had watched its working, and he did not hesitate to express his belief, that the repetition of such a policy, in regard to the arterial lines of India, would retard the development of the resources and the trade of that great empire, and effect an injury so great as to be out of all proportion to the slight saving to be effected, by filling up the connecting links of the great chain of communications between Kurrachee and Peshawur with lines of the mètre gauge.

General Sir Lintorn Simmons, R.E., K.C.B., by permission of the Council, and through the Secretary, said, that having been an Inspector of Railways at the time of the great war of the gauges, he could not conceive how any one could have arrived at the estimate of £1,000 per mile, as the difference of cost between two railways identical as to their powers of conveying traffic and in every other respect, except as to gauge. This, which was the

only ground upon which the Author, as the mouth-piece of the Indian Government, had based his argument in favour of a change of gauges, had been entirely disposed of by the statements of Mr. Harrison, Mr. Hawkshaw, and Mr. Bidder. General Simmons believed the estimate of Mr. Fox, that there would be a saving of £200 per mile, was much nearer the truth. General Strachey's argument, that the question was only capable of solution by those who had lived in India, and who were, therefore, conversant with the peculiarities of the country, sounded strangely after a statement of the case for the Government, in which the Author based his calculations on reports and estimates by Mr. Fowler and by Mr. Hawkshaw.

The question was not one of the abstract merits of the two gauges. If there were no railways in India it might be an open question, whether the 5 ft. 6 in. gauge, or any other gauge, should be adopted; but now that 5,000 miles were in operation on the 5 ft. 6 in. gauge, the question was, as the Author had put it, one for the comparison of prime cost, in conjunction with that of the relative expense and inconvenience of working the two gauges.

The cost of construction having been disposed of, there remained the cost of working. On this there could be little doubt that two otherwise identical railways would, as Mr. Fox had stated—as the result of his Canadian experience—be worked without any appreciable difference of expense, either in haulage or maintenance. As to the inconvenience and difficulties occasioned by a break of gauge, they were far more serious than the Author had any idea of. It was not a question of break of gauge merely at one or two points in the Punjâb, but at every point at which the 10,000 miles of railways, the construction of which was contemplated, would come in contact with the 5,000 miles of existing railways. It was impossible to foresee the number or position of the points of junction, but each would involve a break of gauge and a multiplication of the difficulties of which, in the Paper, account was only taken at two or three stations in the Punjâb. The estimate of the inconvenience at these stations was also taken inordinately low. Thus, for instance, the total traffic passing through Lahore in 1870-71 was stated to be 526 tons. The Author said:—"Supposing that, on the completion of the Lahore and Peshawur railway, these quantities will be doubled—becoming a total of 1,052 tons." How did this estimate agree with the experience gained in England, where it was well known that the traffic taken on the best roads, and proved

before Committees of both Houses of Parliament in support of railway Bills, had not only been doubled, but had been multiplied a hundredfold? If this were the case in a country like England, abounding with excellent roads, it stood to reason that the ratio of increase must be far greater in a country where previously existing roads were not so good; and it could not be conceived how the Author, or the Indian Government, could accept such a meagre measure of the increase of traffic due to such an improved means of transit. It appeared simply monstrous, that such an estimate should be taken as a liberal measure of the increase of trade, to be brought about by the introduction of railways into a populous country, hitherto devoid, to a great extent, of any good means of communication.

The commercial estimate of the inconvenience of the break of gauge was, however, a small matter compared to the military aspect of the question. As a soldier, General Simmons protested, in the strongest possible way, against the low estimate of inconvenience caused by a break of gauge in, what would become, the great strategic lines of communication throughout India. Here again the Author did not appear to have grasped the importance of the question. It was not merely the delay and difficulties which would be caused by changes at Mooltan and Lahore, which had to be considered, but those which would occur at every station, throughout India, where the two gauges would meet. Much had been said recently of the Central Asian question and of the possibility of Russia attacking our Indian possessions, which the Author instanced as one of the only conceivable contingencies in which the presence of larger masses of troops could be required in the Punjâb, all of which contingencies he said could not fail to cast their shadows before them. Now a more dangerous line of argument could not be conceived. General Simmons was one of those who did not believe that a direct attack from Russia was by any means the greatest danger which could happen to the Government in India; but when attention was directed to the greatest miracle of this present wonderful age, the fact invariably started up that a small island, in Europe, was holding in subjection a population of 200 millions—nearly equal to the whole population of Europe—including some of the most warlike people in the world, by a pigmy force—relatively to the stake at issue—of about 60,000 British soldiers, backed it was true by native troops, but the fact was undeniable that the mainstay of the British power in India was this small and, numerically speaking, insignificant British force. Some persons, who knew India, were of opinion that

the natives were so severely punished at the time of the Mutiny, and so thoroughly disarmed, that they were not likely to rise again and to attempt to overthrow the Government. This might be true in the present generation, but this legislation as to railways was for all time, and no man could say, at the pace at which the world was now moving, how long it might be before some of those natives might be ready to move again. It was true they had little or no artillery, and it might be possible to prevent them from acquiring any, but no power could prevent them from acquiring rifles; and in these days of telegraphs, perfected postal arrangements, railways and better education, combinations which were formerly impossible became comparatively easy, and there could be no doubt that rifles in great numbers would more than counterbalance a deficiency in artillery. The native army was now nearly as large as it was formerly, and who could say whether in a few years, as the effect of the putting down of the late Mutiny wore off, that the native army would always remain faithful to the British Government, and would not again rise in mutiny against it? If such contingencies were possible, and the most decided optimist could scarcely gainsay their possibility in a future generation, what was the greatest danger that the present or some future generation might have to encounter in India? The greatest danger to which British power in India was exposed was within our own frontiers; it might be fomented by a foreign power, but, however brought about, it would be within our own territory. What then should be the military policy? To have the troops well in hand, and ready to strike hard at any point which might be threatened with disturbance. Delay would, as in the case of the late Mutiny, add to its violence, and hence the necessity of being able to send forces in any direction, and possibly in more directions than one at the same time, without the least hesitation, to stamp out the sparks of disaffection before they burst into flame.

Suppose for an instant that a rising were to take place in the Punjâb, and that the Sikhs got possession of, or destroyed the rolling-stock of the Punjâb railways, what would be the effect on the movement of British troops into and through the Punjâb, if they had nothing but broad-gauge stock available? or *vice versâ*, if the people south of the Indus got possession of the broad-gauge rolling-stock, what would be the effect upon the movement of troops from the Punjâb upon Delhi? This difficulty would be equally felt all over India, wherever troops might have to be moved, north, south, east, or west, and wherever a junction occurred

between the 5,000 miles of existing railway, and the 10,000 miles of contemplated railway. There could not be any doubt that by constructing 10,000 miles of railway on the mètre gauge, to supplement 5,000 miles of already existing lines on the 5 ft. 6 in. gauge, the military force in India would be deprived of half its efficacy.

There was some experience, as a guide in these matters, although it was difficult to estimate its full importance; but recently a million of men had been seen invading a foreign country, and an immense army supported for months, while reducing its capital, in a way which would have been utterly impossible without the aid of railways. The difficulties of those operations were greatly enhanced at times by obstructions in the railways. If the fortress of Toul had been able to hold out, the obstruction to transport caused by a break in the line from Germany to Paris, added to an injured tunnel, would have made the operations before Paris much more difficult, if not impossible, and, in fact, the destruction of a viaduct near Nancy, a few days before the capitulation, produced the greatest inconvenience to the German army. Now an interruption of this nature was very little more serious than a break of gauge; and if the opinion of the German generals could be taken, they would no doubt bear testimony to the enormous advantage they derived from being able to make use of German rolling-stock on the French railways, in addition to the immense quantity of rolling-stock which they captured on the French lines. From the quantity of German railway stock which General Simmons had seen on the French railways during the invasion, he doubted whether it could have been carried out so rapidly and efficiently as it had been if a break of gauge had intervened to prevent the use of the German carriages.

It would be said, and in fact the Author did say, that large bodies of troops would not require to be moved; but the camp followers, who were essential to the existence of an army in India, were well known to be as numerous, or even more so, than the armies themselves, and those camp followers had all to be fed and cared for, as well as the actual combatants. Therefore the arrangements must contemplate large numbers, all of which should be moved and supplied with a regularity of which clockwork was but a type, and, in order to be effective, with the greatest possible speed.

The operations of an army in war time included, in addition to the supplies, the removal of the sick and wounded, whose sufferings a break of gauge might greatly aggravate. The German wounded were taken many hundred miles into the interior of their own

country, without being moved from the carriages—expressly fitted in Germany for the purpose—in which they were placed almost on the fields of battle. In India, also, where appliances for the preservation of food did not abound, the power of bringing up live stock to feed the British soldiers, who were accustomed to fresh meat, would be greatly interfered with, wherever a break of gauge intervened; as also the supply of horses, and all stores, whether warlike, clothing, food, or whatever their nature might be.

What then must be thought of estimating the military inconvenience of making 10,000 miles of the mètre gauge in all parts of India, by disposing of it with a remark, that a regiment could be shifted from one train to another in half an hour? a statement which in itself was totally devoid of proof, and was contrary to the experience of every man who had ever seen a regiment equipped for active service.

If a break of gauge had existed on the lines in Germany, the army, instead of taking less than three weeks from the first order for its mobilization, until it had concentrated and struck its first blow on the soil of France, on the 4th August, 1870, followed by two others on the 6th, which might be said to have almost settled the issue of the campaign, would have been crawling along in the interior of Germany, changing from train to train, and assembling behind the fortresses of the Rhine for another fortnight or three weeks, during which the Rhine provinces might have been overrun, and possibly a blow might have been struck at the South German states.

Under such supposed circumstances the trifling saving of expense arising from the mixture of gauges would have been more than a hundredfold repaid by the misery and ruin wrought upon the country. It was spared such a disaster entirely through the concentration of the army, which was only possible with continuous and unbroken lines of railway.

It was objected that the broad-gauge rolling-stock, now existing in India, could not traverse light broad-gauge railways, constructed as the lines on the mètre gauge were to be, with light rails. That was a fallacy as regarded all the stock—except, perhaps, the engines—and even the greater part of those engines might traverse them at slow speeds—but as traffic increased, by the natural law of development, which invariably followed the introduction of improved facilities for transport, the light rails would be replaced by heavier rails, and then the objection would disappear. On the contrary, when the light rails, now proposed to be laid, on the mètre gauge, came to be replaced by heavier rails, where would be the estimated

economy of construction? and the interchange of rolling-stock would be impossible.

A break of gauge could no more continue for ever in India than in England. The time would come, therefore, if those 10,000 miles of railway were made on the mètre gauge, when the 5,000 miles of existing lines would have to be altered, the expense of which must be set off against the anticipated saving. This unification of the gauges might be deferred for many years, but what dangers might not occur in the meanwhile; and during all those years the British policy would be cramped and the hold of the country weakened by a policy which, for a paltry saving, would have deliberately deprived the British Government in India of a very large proportion of its power and strength.

Mr. E. W. Young, by permission of the Council, and through the Secretary, stated that he had superintended the construction of a railway of 3 ft. gauge in Nova Scotia, and his experience had much impressed him with the capabilities of narrow-gauge lines. The railway to which he referred was constructed for the Glasgow and Cape Breton Coal and Railway Company. It was about 18 miles in length, exclusive of branches, and had been built to carry coal from several new mines. The rails weighed 50 lbs. per yard, the ruling gradient against the traffic was 1 in 100, and with the traffic 1 in 75. The wagons weighed about 1 ton 18 cwts. each, and the break wagons about 2 tons, carrying 4 tons of coal. These wagons were somewhat heavier than an ordinary freight wagon, in consequence of a peculiar structure, which had been adopted to enable coal to be shipped with rapidity. The Fairlie engines, which were used, would each take a train of 35 cars, weighing about 207 tons, up the gradient of 1 in 100 at 10 miles per hour with a pressure of only 100 lbs. of steam. As they were warranted capable of working up to 140 lbs. of steam, their power must have been still greater, the adhesive power of the engine being not far from 4 tons. The sharpest curves—in or close to stations—were 5 chains radius. He had frequently seen a train of empty wagons—which were more likely to get off the rails than when they were loaded—occupying with the engine nearly a whole quadrant of a circle, pushed up a gradient of 1 in 75 along a curve of 5 chains radius, there being no guard rail, at the rate of about 6 miles per hour. The running of the engine and its train was remarkably smooth; the train, as seen from the engine, when running along a piece of straight line, generally appeared like a rigid structure.

These facts were sufficient to show the great capabilities of a 3 ft. gauge, and would, he thought, prove that lines of the

mètre gauge were perfectly capable of carrying all the traffic that they were likely to be called upon to accommodate, in India, for the next few centuries. It was argued by the opponents of the mètre gauge, that light railways on the broad gauge could be made at a cost not much in excess of that of the narrow gauge, and that the estimates, put forward by high authorities, of the saving expected to be realised by the adoption of the mètre gauge were fallacious. In answer, it might be said, that even if the same weight of rail were used in both cases, the saving in first cost was quite enough to make it profitable to adopt the narrow gauge—in spite of the break of gauge, and without reckoning the great advantages of a lighter and handier rolling-stock. But it was not necessary to enter minutely into the matter, to understand that the working expenses and the cost of repairing would be greater on a light broad gauge than on a narrow gauge; for the injury to a light permanent way under traffic of wagons weighing 12 tons each, or thereabouts, when loaded, must be far greater than with double the number of wagons weighing only 6 tons each. Even the engines on the broad gauge, if of the same power as those on the narrow gauge, must be somewhat heavier. As the traffic in India was certain to be light, there must be a constant running of partially-loaded wagons. The greater the capacities of the wagons the more unprofitable dead weight was likely to be carried. On the other hand, to make the capacity of the broad-gauge wagons only equal to that of the narrow-gauge wagons would involve a great waste of material, the wagons would be nearly all 'underframe,' and their weight much greater than that of the properly proportioned wagons of the narrow gauge. In short, it appeared evident that any attempt to rival the narrow gauge, with its permanent way and rolling-stock properly proportioned to one another, by an emasculated broad-gauge system, must be a failure.

The injurious effect of a break of gauge was another objection urged against the proposed introduction of the narrow gauge, and the case of the English Great Western railway was cited. But the cases were entirely different. In the one case the traffic was heavy and the lines short, in the other case the traffic was light and the lines long. The trivial character of this objection would be seen, when it was considered that in America there were many different gauges, and in some cases railways had been made purposely of a gauge different from those with which they were connected. Moreover, it was possible to alter the gauge of the existing lines at a future time; and this was now being done to

the extent of thousands of miles in Canada. During the change, a third rail, or intermediate rail, could be laid down, which, however, he thought would be found to be unnecessary.

Another objection insisted upon against the mètre gauge, especially with reference to the Indus Valley line, was, that its carrying capacity was so small, that in the event of a war with Russia it would be impossible to bring up troops and munitions of war with sufficient rapidity, from the coast to the interior. The answer to that objection, and, indeed, to all objections against the carrying capacity of narrow-gauge lines was, that in one sense carrying capacity might be said to be independent of gauge, but dependent upon the amount of rolling-stock at hand. The total horse power of the engines, and the total cubic space of the wagons, represented the carrying power, whether the gauge was broad or narrow. With an unlimited supply of rolling-stock an army and its 'matériel' could be transported with all desirable rapidity.

The main argument in favour of the narrow-gauge system was, that at least the same income could be earned by its means as by the broad gauge, on an amount of capital considerably less than would suffice to build an equal length of broad-gauge line. He agreed with other narrow-gauge advocates in thinking, that the percentage of working expenses on the narrow gauge would be less than on the broad gauge, and therefore that the former would earn the larger income.

It had been stated that the great want of India was a sufficiency of ordinary roads to feed the railways. Now, although he had no personal experience of India, he could easily imagine that the construction and maintenance of roads in a tropical country, with its dense jungles, alluvial plains, monsoons, and rapid growth of vegetation, might be a very expensive matter; and he should not be surprised if it would be found cheaper to construct wooden tramroads—with rails of wood faced with angle iron, or with very light iron rails—on which the wagons of the mètre gauge could be drawn, by bullock power or horse power, to large villages situated a few miles away from the course of the line. By constructing such tramroads, where steam power would not be used, the advantage of having to provide for the transport of wagons weighing only 6 tons instead of 12 tons was very apparent.

Looking at the facts that India was not a manufacturing country, that its population was poor, its climate enervating, its beasts of burden diminutive, its labouring classes physically weak, and the loads they were accustomed to handle small, he could not help thinking, that if there was any country in the world to which the

narrow-gauge system, with its light and handy rolling-stock, was suited, that country was India.

Mr. G. G. HEPPEL, by permission of the Council, and through the Secretary, said it had come to his knowledge that in the statement read by Mr. Rendel, the following remarks occurred:—"A 42-lbs. rail on a broad-gauge line in India was no new thing. It was tried on the Oudh and Rohilkund, broke down under the wagons of the East Indian railway, and was taken up, and replaced by a 60-lbs. rail; he knew that it was alleged that the failure was owing to conical wheels being run on flat rails. He did not believe this was the cause of the failure, and he did not believe that any one here would say it was so."[1]

Now, as that statement was put forward by Mr. Rendel as an argument against adopting light broad-gauge lines in India, and as it was not strictly correct, Mr. Heppel would give the exact state of the case.

Firstly, then, as regarded the weight of the rail. The rail used on the Lucknow and Cawnpore branch of the Oudh and Rohilkund railway—42 miles in length—was 36·37 lbs. per yard; nothing between that and the 60-lbs. rail adopted for the whole system of the Oudh and Rohilkund had ever been used on that line. It was of a very weak section as regarded the head, having been designed with a view to obtaining extra strong joints, so that the rail might be of uniform strength throughout.

Secondly, Mr. Rendel did not believe that the failure was due to the running of conical wheels over a flat rail. There was certainly nothing incorrect in the statement, but as he presumed that Mr. Rendel also expected other people to be of the same opinion, Mr. Heppel would here state that the cause of failure of this rail was due to the fact, that the Company, not having sufficient rolling-stock of their own, borrowed the heavy stock of the East Indian Railway Company, which, of course, had conical wheels, and ran it over their rails, which were laid flat; this caused the rails to laminate, and in some cases the heads were bent down. Added to this, the rails were laid on light corrugated iron sleepers, which had no hold whatever on the ballast, and they were fastened to them only at the centre of each sleeper. The tendency of the sleeper, therefore, was to stretch out into a flat plate. The sleepers were $\frac{1}{8}$ in. thick.

He did not, therefore, think that the failure of a line constructed with a very defective section of light rail—36 lbs. per yard—laid flat,

---

[1] *Vide* ante, p. 147.

on corrugated iron sleepers, to which it was imperfectly fastened, and run over by heavy wagons with conical wheels, could be taken as a conclusive proof that light broad-gauge lines could not be satisfactorily constructed and maintained.

He made these remarks, as the statement made by Mr. Rendel would induce prejudice against a system of light broad-gauge lines; which, considering the mileage now open in India on a broad gauge, was, as he believed, the only practical way of obtaining economy in the working and maintaining of new railways. He would suggest a rail of from 42 lbs. per yard to 45 lbs. per yard, on wrought-iron sleepers, or, if possible, on longitudinal timber sleepers.

Mr. J. Grierson, in a communication authorized by the Council, and through the Secretary, stated that as the case of the Great Western railway had been frequently referred to, it was desirable to notice that, within a recent period, that railway—exclusive of broad-gauge lines towards Plymouth, Penzance, &c., in which the Great Western Railway Company was interested with other companies, and irrespective of narrow-gauge lines, north of Hereford and Wolverhampton, which it owned jointly with other companies—consisted of 770 miles of broad gauge, 175 miles of mixed gauge, and 455 miles of narrow gauge; making a total length of 1,400 miles. The rolling-stock consisted of about the same number of carriages and wagons—exclusive of private stock. The engines were in number equal to about five-sixths of those of all the railways in India. There were about 20 points at which the broad gauge and the narrow gauge met, thereby rendering changes of carriages and transfers of merchandise and minerals necessary. The tonnage transferred in the course of a year had varied from about 500,000 tons to about 750,000 tons, and the number of cattle, sheep, pigs, &c., 40,000 animals to 50,000 animals. It would thus be seen that the officers of the Great Western railway had considerable experience in the working of the two gauges and of a break of gauge.

The objections to break of gauge which were most readily apparent, and which had been most dwelt upon in the course of the discussion, were the cost of transfer, the damage to the goods, and the delay consequent on the transfer. His experience, however, prevented him from concurring in some of the strong statements which had been put forward upon those points. The cost of transfer from one gauge to another under certain circumstances might and did become considerable, but where proper accommodation was provided, and where no blockage took place, the average cost of the actual transfer varied within moderate figures

which any person of experience in general business might fairly estimate. The cost also varied with the nature of the goods handled, whether pig iron, teas, or furniture. He might state that in the calculations which were made for the Directors of the Great Western Railway Company as to the probable effect which the alteration of the gauge in South Wales would have on the revenue, the money value of the saving to be effected, where transfer would be done away with, and the additional cost which would be incurred where new points of transfer would be created—by the alteration of the portion of the system between Swindon and Milford with the branches—was put down at 5*d.* per ton. It would be safe, however, on similar traffic, irrespective of damage to goods or waste in minerals, to allow 6*d.* per ton.

As to the damage to goods from a transfer, which in the course of the discussion had been stated by some speakers to amount to as much as 2*s.* 6*d.* per ton, his experience did not confirm so large an amount as anything like the average cost; and that it was not, and could not be so great, would be readily understood, when it was considered that the removal of goods from a warehouse to a cart, from the cart to a railway wagon, and from the latter again for delivery, were practically equal to breaks of gauge; and that while a very large amount of transfer business was carried on at all the principal railway junctions in the country—even where the gauges were uniform—no such damage to the goods, on an average, did take place.

It was, of course, true, that in the course of transfer from one gauge to another very serious damage and loss did sometimes occur, but the average cost of the damage depended on the class of goods to be transferred, the accommodation provided for the purpose, the time allowed for the work, and the class of men employed to perform it.

As a proof that the assumption of anything like 2*s.* 6*d.* per ton as the value of the damage arising from transfer was erroneous, he might state, that in 1870, about 200,000 tons—out of the total tonnage transferred by the Great Western Railway Company—were general goods, so that, assuming 2*s.* 6*d.* per ton as the amount of compensation under this head alone, it would have amounted to £25,000, whereas the total sum incurred by the company, in the year, was only about £16,500, and this included not only damages from transfer, but all claims for theft, damages, delay, and loss on 2,944,273 tons of general goods, and 8,000,000 tons of other traffic—so far as the company was liable for any loss—as well as on 2,956,291 parcels, and also on passengers' luggage; showing conclusively that the

damage to goods from a transfer was much over-estimated. The truth was, that some of those who were opposed to a break of gauge, under any circumstances, had very much exaggerated the cost and damages arising from a transfer from one gauge to another, while some of those who were defending a policy which would create a break of gauge overrated the importance of being able to show that this was the case, whereas the real objections to a break of gauge under certain circumstances were of a more substantial and different character, although not so readily seen or understood.

With regard to the delay arising from passengers having to change, or from goods having to be transferred from one gauge to another, he might state that the more or less serious nature of that difficulty depended entirely upon the circumstances of the case. Where traffic was not great, when it was regular, and when sufficient accommodation and rolling stock were provided, and where no sudden emergency arose, the delay or inconvenience was comparatively small, except in the case of mineral traffic and heavy or bulky articles. In the west of England, for instance, where the traffic was to a large extent of that character—and possibly not very dissimilar from that of certain parts of India, except that time in transit was a much more important element in England—the delay and difficulties arising from a break of gauge were not of a serious nature.

With regard to the construction of new lines of railway, on a different gauge from that of existing lines, with which they were to form a connection, he could quite understand that there would be and were cases, in every country, in which that was a necessary and even desirable course to adopt; it was so, to some extent, in Great Britain and in Ireland. He knew of one railway on a 3 ft. 6 in. gauge, which was being constructed from the railways on the 5 ft. 3 in. gauge, from Ennis to the coast of Clare; and, if uniformity was not followed out to the extreme in Ireland, the same reasons might to a greater extent prevail in certain districts in India, where, from the nature or amount of the traffic, the character of the country, or other circumstances, narrow-gauge branches would be sufficient for all commercial purposes without any serious countervailing disadvantages.

It had been stated, in the course of the discussion, that the case of the Great Western railway could not fairly be compared with the position of railways in India, a statement in which he, to some extent, concurred; but it had also been said that the Great Western Railway Company, in recently making a considerable alteration in the gauge of their railways, were induced to do so for the purpose of

competing with other lines of railway for the traffic of South Wales, and not because there was any serious disadvantage in a break of gauge; a statement which was not correct. Every person acquainted with the position of the railways between London and South Wales must be aware that the Great Western Railway Company possessed, in addition to the broad-gauge line between London, through Gloucester and South Wales, to Milford, a parallel narrow-gauge line through Gloucester, Hereford, and Merthyr to Swansea, which was considerably shorter than the route of any competing company, and by which they had access to all the principal ports, iron works and collieries in the district, and over which the greater portion of the South Wales mineral traffic was still carried. This being so, if there had been no other object in view it would not have been necessary, for the sake of competition, to have altered the broad-gauge lines.

It had also been stated, or inferred, first, that the broad gauge was more expensive to work, and secondly, that it was in other respects a failure, and therefore had to be abandoned. A comparison between the working expenses of the Great Western railway and any other large railway would, however, conclusively show, even when a large mileage of mixed gauge was being worked, that the first statement was not correct. As to the other statement, he could positively affirm that the change of gauge, on certain portions of the line, did not arise from any objections to the broad gauge, other than a desire to prevent a break of gauge. Indeed, some of those, who were best able to express an opinion, considered that the broad gauge, although objected to in mineral districts on account of the additional cost of constructing sidings, &c., had not been tried to anything like the maximum of its capacity for the conveyance of passengers, and that the improved carriages and arrangements which could have been adapted to it could have been made to afford such comfort and accommodation to passengers as had not yet existed in the United Kingdom.

The desirability and even necessity, however, of adopting a uniform gauge throughout South Wales had been long foreseen and looked forward to by the Directors; for although during a portion of the year the traffic was moderately regular, at other times it was fluctuating, and it was therefore frequently found, when this fluctuation arose, or when the traffic had to be carried over distances, sometimes short and sometimes long, that it was impracticable to provide the rolling-stock with regularity, notwithstanding the large amount of stock owned by the company, which was largely supplemented by stock owned by private persons; and thus the

transfer stations became blocked; uncertainty, delay, and loss were thereby caused, and a check was given to progress and development, whereby the interests of the districts, the company, and the traders suffered.

The following was an extract from a memorial which was signed by or on behalf of 269 firms of manufacturers, merchants, colliery owners and others, in 1866, addressed to the chairman and directors of the Great Western Railway Company, for the extension of the narrow gauge throughout the South Wales line:—

"The undersigned, being deeply interested in the minerals, metals and commerce of South Wales, desire respectfully to represent to the Directors of the Great Western Railway Company the serious impediments, inconvenience and loss the commerce of the district is sustaining, in consequence of the broad gauge being, in many cases, wholly inapplicable to their wants: thus confining their communications to very circumscribed limits, arresting their operations, and consequently crippling their trade.

"The transfer of goods, in consequence of the break of gauge at every port and principal station between Milford and Gloucester, is expensive and tedious, entailing, moreover, constant delay in delivery, grievous disappointment, consequent annoyance, and often serious loss to both consignor and consignee; and as regards the great staple of this district, viz. coal, such transfer (involving not only the expense of the operation, but the loss arising from depreciation by breakage) becomes positively prohibitory. The undersigned therefore desire strongly to represent, that the early adoption of the narrow gauge along the whole of the South Wales line is imperatively called for by the necessities of this district."

In consequence of this memorial, and the strong belief that the trade of South Wales could not be properly developed, except on one uniform gauge—it being clear that trade was retarded as well as loss sustained beyond the cost of transfer of the coal, &c.—to overcome the difficulties of the fluctuation of the traffic, the sudden emergencies that therefore arose, and the transfer—the Great Western Railway Company, in the summer of 1872, expended about £600,000 in altering 273 miles of railway west of Swindon, providing extended sidings—rendered necessary by the narrower gauge rolling-stock—and in other matters incidental to the change.

It had been stated in the course of the discussion that the improved position of the Great Western Railway Company was to some extent attributable to this change, as well as to the removal, in 1869, of the broad gauge from the lines north of Oxford and Gloucester; but this was a mistake, as, under any circumstances,

the alteration of gauge in South Wales had not been long enough in operation to have had any material effect upon the traffic. The feeling, however, throughout South Wales was universal, as to the advantages which the trade of the country as well as the traffic of the company would derive, from the existence of an uniform gauge throughout the district; indeed, although the alteration of gauge only took place in May, 1872, the ironmasters and others had already benefited considerably by the change.[1]

With respect to the new lines in India, he understood the position to be, that about 5,000 miles of lines had been made, at a cost of about £90,000,000, and that it had been determined to provide 10,000 additional miles of lines, and the question was, whether they should be constructed upon the standard gauge of the existing lines, or upon a new and narrower gauge. It appeared that the proposed lines were so laid out that there would not only be twenty-one points at which there would be a break of gauge, but also—if no mixed gauge was provided—that there would be eleven separate systems having no through communication with one another, and therefore that these would practically possess as few advantages, in respect of through communication, as if they had been constructed upon eleven different gauges. There was no experience of that kind in England, the only case having been that of the West Cornwall railway from Truro to Penzance, which was upon the narrow gauge, while the lines connected with it were upon the broad gauge. When that line became the property of the broad-gauge companies that state of matters was immediately altered. With that exception, the whole of the broad-gauge rolling-stock and the whole of the narrow-

---

[1] As instances, it might be mentioned that one firm informed Mr. Grierson that they had, up to the end of that year saved £1,000 by the better working of their trucks; while another well-known firm made such a statement to him on the same subject, that he was induced to write them to ascertain whether he had misunderstood them, and he received the following reply:—

"5, Queen Square, Westminster, S.W.
"*March 3rd*, 1873.

"MY DEAR SIR,

"I have not the slightest objection to your making use of the statement I made to you as to the effect upon us of the change of gauge.

"The expression, however, should be, not 'that it saved us £20,000 per ann.,' but that it made a difference to us in our business of fully £20,000 a year. With this modification, you are quite at liberty to make any use of the statement, and, if you see advisable, I put no restraint on your mentioning names.

"Yours faithfully,
"ALEX. BROGDEN.

"J. GRIERSON, Esq.,
"Paddington."

gauge rolling-stock had been available for working throughout, on the broad-gauge system and the narrow-gauge system respectively.

From the Paper it would appear, that the main reasons for proposing the construction of the new lines upon the mètre gauge, instead of the standard gauge, were that the existing railways in India had only paid 3 per cent., and that the Indian Government had to make up the difference between that and 5 per cent. In considering that argument, the first question that naturally arose was, whether the existing lines had been as economically constructed as they might have been, or whether any special circumstances had arisen which had increased the cost beyond what would now be incurred, in respect of the new lines proposed to be constructed? Whether this were so or not, it appeared to be an extraordinary and a fallacious argument to put forward, that the gauge of the remainder of a great system of railways in India should be fixed by the amount of dividend which a portion of the system had earned in the earlier years of their existence. If this were a proper principle by which to be guided, then the Great Western railway, which for the last twenty years had yielded an average dividend of rather less than 3 per cent., ought not only not to have been made on the 7 ft. gauge, but should have been made on a 3 ft. gauge; and in the case of the Scinde railway, which had expended upwards of £9,000,000 on 667 miles of railway—but which, according to the last returns, had practically yielded no return whatever—it would follow that the line ought not to have been made at all. If the proposed lines had to be made simply in the interest of those who provided the capital, irrespective of every other object or reason, the question might assume a somewhat different form; but the Indian Government would not only be the owners or guarantors of the capital, but they also represented and were most deeply interested in the land, commerce, and welfare of the whole country, which would, by the construction of railways, be benefited far beyond any difference between the net earnings of the lines and the interest on their cost. That this had been the case in England, was beyond dispute; and even in Ireland, where there had not hitherto been the same development of trade and commerce, the knowledge that the value of railways to a country was not to be measured by the dividends they paid, was shown by the counties, such as Kerry, Galway, Waterford, Limerick, &c., having guaranteed, and now guaranteeing, the interest on the capital, or a portion of the capital, of the lines which had been and were being constructed through those counties; and yet the interest of, and the advantage to the Indian Government in the construction of new rail-

ways in India, exceeded that of the Irish counties. The Author, however, had stated that the proposed lines were expected to be "strategically and politically, as well as commercially, useful." Now, if there was one reason more than another which in Mr. Grierson's judgment should weigh powerfully against any break of gauge, on trunk lines, in India, it was that they might be required for strategic purposes. Any state of circumstances requiring the use of the railways for strategic purposes would make it desirable, and probably absolutely necessary, that there should be certainty, rapidity, and the power to make use of every available means of transport; but the contingencies of a state of war on any large scale, coupled with a break of gauge and a comparatively small amount of rolling-stock, would almost assuredly result in confusion, delay, and disappointment.

Allusion had been made by Mr. Hawkshaw to some inquiries and calculations which had been undertaken, to show in what way and in what time large masses of troops could be conveyed from one part of Great Britain to the other, in case of invasion, and as Mr. Grierson was cognisant of the matter, he might state that while the result showed that, with proper arrangements, the movement of troops in the United Kingdom could be carried out with a facility and to an extent which had not been, and probably could not be done in any other country, at the same time, although it appeared that there would be about 10,000 engines, 35,000 carriages or vehicles suitable for traveling in passenger-trains, and 250,000 goods wagons and cattle wagons, available for the purpose, yet in cases of sudden emergency, or in large movements, it was evident that some delay might arise in certain places in concentrating the rolling-stock required for the purpose. If this might be the case, in certain cases, in England, where the amount of rolling-stock was so great, what would be the practical working in India, if the lines were constructed on different gauges, with a limited and isolated amount of rolling-stock, such as would be the case, for instance, on the Lahore and Peshawur line? It had been stated that, on the proposed mètre-gauge line from Lahore to Peshawur, the calculations were made for a provision of only 1 engine and 30 carriages for every 13 miles of railway, and that it would require 200 carriages to convey 1,000 men. If this information was correct, it would follow that—unless such a quantity of spare stock were kept, as would not be required in ordinary times—supposing every vehicle to be available and no irregularity to arise, the largest number of men who could be carried from Lahore to Peshawur, even taking all the stock to be in use in one direction,

would be less than 3,000 at a time; while the working of such a long length of single line could scarcely, in practice, be carried on, under great pressure, without some irregularities in the return of the rolling-stock, upon which would depend the further conveyance of troops, stores, &c.

In the event of war in India, either from civil commotion or from an attempt at invasion, the possession of the railways, or the destruction of their rolling-stock, would probably be a specially important object. If the Lahore-Peshawur line was constructed on the mètre gauge, and the stock, or any considerable portion of it, could be destroyed by the enemy, it would amount to the destruction of the railway itself, for all practical purposes. On the other hand, if the line between Lahore and Peshawur were constructed on the 5 ft. 6 in. gauge, the rolling-stock of all the other lines would be available, and trains could be sent forward to Peshawur continuously until the whole movement was completed, the trains standing on and being discharged, if necessary, upon the main line, and without any necessity arising for returning the empty vehicles, or checking the running of trains from Lahore until the pressure was past.

As previously stated, the difference of gauge in the west of England, in consequence of the nature of the traffic and other circumstances, was not seriously objectionable; but, at the same time, his own opinion was that, if at any time during the last ten years or fifteen years there had been any real probability of the railways in that part of the country being required for 'strategic purposes'—as the Author assumed that the new railways in India might be—the difference in gauge in the west of England would not have existed for five years after such an event had been apparent. The Royal Commission on Railways in 1867 reported:—"We are of opinion that the continued existence of the double gauge is a national evil. We think it worthy of consideration, whether it may not be desirable to require the broad gauge to be put an end to; and as the evil has arisen to some extent from the proceedings of Parliament, whether a loan of public money should not be granted for the purpose, on the principle we have suggested for advances to Irish Railway Companies." From Mr. Grierson's experience of the difficulties which had arisen in dealing with the construction of new lines, where two gauges existed, he should fear that, if the proposed new lines in India were made on the mètre gauge, it would become necessary, at some comparatively early period, to consider—almost irrespective of any question as to the working—the desirability of altering one of the gauges on trunk lines. The longer the time before

such a determination was arrived at, the greater would be the loss in respect of the rolling-stock.

It appeared to him that if the further railway accommodation in India could only be provided by private enterprise, in the same way that railways had been provided in England, and the capital could only therefore be obtained, if an adequate return for such capital could be insured, and if the traffic of the districts through which the 10,000 miles of railway were about to be constructed would not yield a fair interest on the cost of railways, on the standard gauge, it would then, and then only, be a question of constructing railways on the mètre gauge or of having no railways at all, and in such a position he would distinctly say—although it would be a misfortune to be placed in the position of choosing such an alternative—that the railways should be made, notwithstanding that the evil of a break of gauge was incurred.

If, however, it were admitted that railways would develop the resources of a country, so that although they would not directly pay in themselves, they would enrich the country to an extent far beyond the loss of interest—and if the Government, having the greatest interest in the land and the well-being of the country, and having to provide the capital and the railways, and by so doing, at the same time, secured the necessary means of insuring the peace of the country by the rapidity, certainty, and economy by which troops could be moved—then he would most distinctly say that a break of gauge on trunk lines, such as had been suggested, ought to be avoided. If the question was whether India should have 15,000 miles of railway on two gauges, at a cost of £160,000,000, or the same mileage on one gauge at a cost—even assuming the Author's own figures—of £170,000,000, Mr. Grierson would again say that it would be a misfortune to have a break of gauge for the mere saving of 6 per cent. of the total cost; but if there was any portion of India where there should be a continuous gauge it was, in his opinion, between Calcutta, Kotree, and Peshawur.

Mr. George Turnbull, in a communication authorized by the Council, and through the Secretary, stated that as he had been for many years connected with Indian railways, and had spent above thirteen years in India, employed in their construction and maintenance, he felt it a duty to say a few words on this important subject.

In the early part of the discussion it was put forward by a great advocate of the narrow gauge, that whatever were the technical knowledge of the opponents of the proposed change of gauge, they did not possess such a knowledge of Indian local conditions,

or of the administration of a great country, as to render their opinion more than one of the elements in the question. Now he did not concur in that remark, because he held that the general principles of engineering in such questions as that before the Meeting were of universal application, and that the question in itself was one of a purely technical character. He was sure that there was nothing in Indian railways to make them an exception to that rule. He spoke from experience in the matter, as he was well acquainted with the country, having been Chief Engineer on the East Indian railway, and having constructed that line through Bengal, and having had charge of its maintenance after it was opened for traffic. He could confidently assert that there was no special claim for consideration, of matters of gauge, by those who had long resided in India, or by those who had a knowledge of Indian local conditions; but that whatever was good in England was good there, and what was bad in England was bad there also.

The question, as he understood it, was not whether a 3 ft. 3 in. gauge or a 5 ft. 6 in. gauge was the best in the abstract, but whether, having a 5 ft. 6 in. gauge established in India over 5,000 miles, mostly of main lines, and the Government intending to make 10,000 miles of lines more, it was to abandon the 5 ft. 6 in. gauge, adopt the 3 ft. 3 in. gauge, to interpolate a length of 240 miles of mixed gauge on a main line, and to adopt the narrow gauge on the important extension to Peshawur of the greatest main line in India. The objections to a break of gauge, and to a mixed gauge, were so well understood, and had been so fully brought into view and admitted, during the discussion, that it was only the necessity of the most severe economy that would justify the project of the Indian Government. No other plea, but that of economy, had been urged, and there was the greatest difficulty in coming to a conclusion on that point, for the estimates of saving, on excellent authority, varied in round numbers from £200 per mile to £2,000 per mile, which was certainly a most unsatisfactory condition of the question. Moreover, there had been differences of opinion as to the maintenance. General Strachey had alluded to the greater economy of maintenance on narrow-gauge lines; although that officer did not insist upon it, or attempt to prove it. On the other hand, Mr. Douglas Fox stated from his Canadian experience that "there was no appreciable difference between the cost of running a train or of hauling a ton of goods on the 3 ft. 6 in., or the 4 ft. 8½ in., or on the 5 ft. 6 in. gauge." If that were so, the question was narrowed to the cost of construction only. Again, on that point there were discrepancies not easily reconciled; for

example, as to sleepers and ballast, it had been said that 8 in. by 4 in. was the section for sleepers for the narrow, and that 9 in. by 4½ in. was the section for sleepers for the broad gauge. That 9 in. depth of ballast was right for the broad gauge and 6 in. depth of ballast for the narrow gauge; a statement which was simply incomprehensible; because all engineers knew that the strength of the permanent way should be in proportion to the weight put upon it, whatever might be the gauge, and that the strength of the permanent way was ruled by that condition alone. The logical conclusions were, that the calculations of saving in construction were not to be relied upon, because they appeared to be founded on different bases, and that the Government of India might well pause before they decided upon the matter without further investigation. He thought it would be found out eventually that the proposed saving was illusory, and had arisen from a well intentioned, but mistaken view of actual economy.

Assuming that the cost of the permanent way and of the bridges was proportionate to the pressure on the rails, a question at once arose whether a saving by the use of light rails and sleepers, and of a thin coat of ballast, where light traffic occurred, would not effect an almost equal economy, and avoid a break of gauge on the main lines?

Not being one of those who had a special bias for any special breadth of gauge, he would guard himself from being supposed to think that the 5 ft. 6 in. gauge was the best or most suitable for India; but 5,000 miles of railway having been constructed on that gauge, he considered that the proof of the estimated saving in the construction of the future 10,000 miles of railway was so unreliable that no prudent administrators could place much faith in it.

Abundant proof had been given, that heavy traffic could be carried upon gauges varying from 3 ft. to 7 ft.; also it was not to be denied that there were places in India where a narrow gauge would be desirable, if a very small saving could be effected, say, even of £50 per mile to £100 per mile; such, for example, as a line to the Sanatorium of Darjeeling, of about 150 miles from the north bank of the Ganges; which, if made on a line going nearly due south from Darjeeling to Caragola Ghaut, opposite a station on the East Indian line, would be of the utmost service, but could never be a main line, and could never communicate with the East Indian railway except by steamer, because the crossing of the Ganges by a bridge was too formidable a work to be undertaken for the use of such a line. India was so vast a country that there were many

other localities where the cheapest of all possible constructions should be adopted for keeping open communications, otherwise broken off during the rainy season, where, as in Lower Bengal, there was no material for road-making, except burnt clay and broken bricks, the kunkur or limestone nodules being too expensive, and often not to be found at all. This circumstance, although apparently a matter of detail, was in reality one of great magnitude. The development of Indian railways was undoubtedly impeded, in a most serious manner, by the want of 'feeders,' or roads of communication leading to the railway stations. In many places in Lower Bengal, very populous and very fertile, the roads, so called, were unworthy of the name, being merely formed by cutting a trench on each side, and throwing up a low mound for the use of the bullock carts in the dry season; in the rainy season such a track became nearly impassable, and was often deserted, and new tracks were made through the adjacent rice-fields. It was in such localities and under such circumstances that the cheapest of all railways, or tramways would be invaluable. On the other hand, the inconveniences and losses accompanying a change of gauge, or a mixed gauge, on any main lines communicating with each other, were so great as regarded ordinary traffic, to say nothing of the difficulties in the conveyance of troops and war materials, in case of future military operations—a probability which should never be forgotten—that he thought it would be well if engineers, who were authorities in such matters, would enter some protest against the course that was being pursued; and that, as well-wishers to their country, they should at least solicit a reconsideration of this subject, which was of such great consequence to the material advancement of India, and thus possibly prevent a repetition of the serious mistakes which had been made in this and other countries, and which had ended in a return to an uniform gauge, after suffering the punishment of great and unnecessary pecuniary loss.

Dr. POLE, in a communication authorized by the Council, and through the Secretary, stated that he thought it the duty of every one who, like himself, had had to do with Indian railways, to put on record his opinion on the grave question now before the Institution.

He had been greatly astonished at hearing, that the Indian Government had determined, on economical grounds, to alter the gauge, as such a step appeared to him to ignore all the knowledge and experience gained on the subject. He had occasion to study carefully the history of the English gauge question, having been

called on to contribute the chapter on the gauges to Mr. Brunel's lately published life of his father;[1] and Dr. Pole had found, what indeed was evident enough as a matter of reasoning, that one of the most positive results brought out by the controversy was the very insignificant influence that the gauge had on the cost of a railway—the real criterion of expense being the carrying power. It had been shown clearly, that if the Great Western railway had been made of the same carrying power as the London and North Western railway, the extra 50 per cent. width of gauge would have added nothing material to the cost. But Mr. Brunel took advantage of the wide base to add 4 ft. in width to all the works, thus giving the line largely increased capabilities; and yet, with this addition, the extra cost was found to amount only to about £300 per mile to £500 per mile![2] And yet they were told now that several thousands per mile were to be saved by the proposed change of gauge in India.

In searching for the origin of this fallacious movement it became clear that a great logical blunder had been committed at the outset. The authorities, having formed a desire, reasonable enough no doubt, to cheapen railways in India, had, as the next step, assumed, that in order to do so it was necessary to narrow the gauge. It was curious to see how, throughout the Indian papers, whenever economy of construction was spoken of, one scarcely ever found the words 'cheap railways,' or 'light railways' used, but always 'narrow-gauge railways;' a strong symptom of a *petitio principii* having forced its way into all the Indian councils. It would seem as if the authorities had referred to Johnson's Dictionary, and finding 'gauge' to be defined as 'a measure or standard,' they had rushed blindly to the conclusion that the gauge was a measure or standard of railways generally, as regarded their calibre, carrying power, cost, and every element involved in them.

This, however, was not so, as was well known to all who had studied the subject. The introduction of the 'overhang' of the carriages at an early period, in order to obtain enlarged carrying capacity with the narrow gauge that had been then accidentally fixed, had taken away the significance of the width between the wheels as a measure of the works. This was obvious enough; for supposing a certain width of carriage to be given, it was evident

[1] "The Life of Isambard Kingdom Brunel." By Isambard Brunel. London, 1870. Chap. V.

[2] *Ibid.*, p. 129.

that nothing could be gained by the childish and unmechanical step of pushing the wheels closer together under the middle of the carriage; inasmuch as the dimensions of the works must be determined by the size and weight of the vehicle, and not by the cramped width between the wheels. It might be said that the sleepers formed an exception, as they at least might be shorter; but an engineer must be but an incompetent officer, if, having a given load to carry on two points, he could not make his outlay independent, or nearly so, of the width they were apart. For example, the most suitable arrangement for a wide gauge light railway would probably be by laying the rails on longitudinal sleepers, and it was evident that the width apart of these could make but slight difference. As a matter of mechanics and of common sense, the wheels of a vehicle ought to be as wide apart, that is, as near to the edge of the vehicle, as it was possible to place them; indeed, as Mr. Brunel had justly argued, the proper position for them was outside the body altogether, as had been, from time immemorial, the type of all wheel carriages, except those of railways, where the accidental narrowness of the original lines had compelled the adoption of the overhang. It was lamentable to see a wide vehicle standing on a narrow base, and still more lamentable to find the designers and users of such arrangements glorying in what was really a mechanical opprobrium. The only justification for a narrow gauge was when an extremely narrow carriage only was required, and no one would venture to assert that vehicles of 3 ft. wide or 4 ft. wide were suitable for the main lines of our Eastern Empire.

It was no new idea in England, though it might be in India, that if it was desired to reduce the cost of a railway, that might be done independently of its gauge. 'Light railways' of ordinary gauge were common enough. All the early railways were light, while the traffic was yet undeveloped, and there would be nothing new in returning to such lightness, when required, without altering the gauge. Contractors were using light railways every day, but they did not alter the gauge. Mr. Bidder, in his able and exhaustive report[1] of June 14, 1870—which, oddly enough, had been omitted from the published Indian Papers—had given a case where one of the largest companies had lately constructed a line 22 miles long, to accommodate a poor district, with an outlay, including expensive land, of little over £4,000 per mile; it had

[1] Published in Mr. Andrew's pamphlet, "Break of Gauge in India." Second Edition. 1873. Page 74.

all the arrangements of the lightest and cheapest possible character, but its promoters had never dreamed that it was necessary to reduce the gauge.

Another case was on the Great Western railway system, where a light branch, of a few miles long, to the fishing-town of Brixham, was worked by a small and light engine. And yet this was on a 7-ft. gauge.

One of the best examples, however, of a light railway on the standard gauge was one laid down by the Duke of Buckingham, on his own estate near Wotton, a few miles from Aylesbury. The Duke, conceiving that many benefits would arise from extending railway communication through his estate, undertook to make a line from Quainton Road Station, on the Aylesbury and Buckingham line, to a place called Brill, about six or seven miles to the west, with a branch to Wotton, one of the Duke's residences. He entrusted the construction to Messrs. Lawford and Houghton, Engineers, of Westminster, and the line was opened about two years ago. It was called the 'Wotton Tramway,' but why this term was used was not clear, as it was as properly a railway as any railway in the kingdom.

It followed pretty nearly the surface of the land, having gradients in some places as steep as 1 in 50, and curves of occasionally 12 chains radius. The rails weighed 30 lbs. per yard, of the bridge section, screwed down to longitudinal sleepers 6 in. by 6 in., with cross ties at every 12 ft. There were no stations, but at each main-road crossing there was a siding for trucks. The entire cost, excluding land, was £1,400 per mile.

The goods traffic consisted of coal, road metal, manure, and general goods, inwards; of hay, straw, grain, timber, bark, outwards; and of cattle both ways. There was also a coaching traffic of passengers and milk. The trucks were of the ordinary kind, borrowed from the adjoining railways, but they were drawn, at a speed of 5 miles per hour to 8 miles per hour, by a special engine weighing about 10 tons or 12 tons. It need hardly be said that the Duke, though, no doubt, he was anxious enough to reduce the outlay, did not commit the folly of altering the gauge.

Another case was of a railway, of a very peculiar and remarkable character, and of which a description was before the Council of the Institution, and would probably be read at a future time. It was the Rigi railway,[1] near Lucerne. In this case the traffic was of an exceptionally light character, only to convey tourists up the moun-

[1] *Vide* Minutes of Proceedings, Inst. C.E., vol. xxxvi.

tain during the summer. There was only one carriage in each train, and the speed was 3 miles per hour or 4 miles per hour; and, as the line was all on the side of a rock, there was every inducement to reduce the dimensions, and cheapen it to the utmost. Moreover, from the peculiar nature of the railway, it was scarcely to be expected that it could ever be worked in conjunction with any other line.

Here, therefore, was surely a case for a narrow-gauge line, if the system were attended with the wonderful economical advantages claimed for it by the Indian authorities. Yet, strange to say, the Swiss, that eminently practical and utilitarian people, did not see this, but made the Rigibahn only a 'light railway,' of the ordinary gauge.

Railways of this kind had actually been provided for by the Legislature, for in the Regulation of Railways Act, 1868, there were clauses introduced specially authorizing and regulating the construction and working of light railways, but giving no encouragement for altering the gauge.

He might further refer to a Report of a Meeting of the Exeter Chamber of Commerce, in June, 1872, at which Mr. Ellis, the mayor of that city, read a Paper on the subject, after which a resolution was passed directing attention to the great importance of a system of light railways to Exeter and the neighbourhood. Mr. Ellis began his Paper by the following words: "Almost every one is now inquiring what is a light railway?" It need hardly be said that the Chamber of Commerce did not arrive at the answer given by the Indian Government to the same question, namely:—"That it must be a railway of an exceptionally narrow gauge."

What became, therefore, of the Author's assumption, that practically the broad gauge was never adopted, except when broad, heavy vehicles were used; and, that in any comparison of the two gauges, that intention might always fairly be assumed? That might be all very well as an opinion hazarded by an amateur, but both reason and experience showed it to be a fallacy.

It had been said by Mr. Gladstone in the House of Commons a short time ago, that "in the battle of the gauges, fought in this country thirty years ago, nothing could be more decisive than the victory of the narrow over the broad, and of uniformity over diversity." Now, as Dr. Pole claimed—as he had before stated—some knowledge of the proceedings in question, he must assert that this statement was calculated to mislead. What Mr. Gladstone called the victory of the narrow gauge over the broad gauge did not arise from any inferiority of the broad gauge, or any superiority of the narrow gauge; on the contrary, the advantages of Mr. Brunel's

system were fully borne out by experience. The victory was wholly and solely due to the impossibility of tolerating a break of gauge. This it was which abolished the exceptional system in the North, and would probably, ere long, abolish it in the West also. And it did not require a great stretch of imagination to anticipate a similar result in India. The time would come when, if the traffic extended, the break of gauge would be found intolerable there also, and then either the narrow gauge must be widened, or the broad gauge be narrowed, and the Indian railway system would become the laughing-stock of the world.

He might add that he had now charge of the Imperial Railways of Japan, which had been laid out, before his connection with them, on a gauge of 3 ft. 6 in. He did not find this to be any advantage, but the reverse. He had reduced the vehicles to as small a size as he dared, but he could not provide for the traffic with a less width of vehicles than about 6 ft. 6 in.; and under this condition, the narrowing of the wheel breadth only gave rise to bad and inconvenient construction, both of the engines and carriages, while it saved nothing in the cost. It was under consideration whether the gauge should not be widened before the evil became too much extended.

Dr. Pole must conclude by adding his protest to that of all other Engineers, against the narrowing of the Indian gauge, unless it could be conclusively shown, which certainly had not been done, that the desired economy could not be obtained in any other way. The subject had been much complicated by masses of figures, exhibiting, no doubt, some discrepancies, according to the views held by different individuals; but there was no technical mystery about it, and the common-sense application to it of ordinary mechanical principles and ordinary laws of construction would, he was convinced, suffice to show that the Indian project was founded on a delusion, and that the judgment dictated alike by reason, by experience, and by the universal opinion of those most competent to judge, was the correct one.

Mr. J. E. Tanner, in an authorized communication through the Council, stated that the Author, while asking for pity for the Indian tax-payers, should have reminded those who were unacquainted with India that the guaranteed railways were the pioneers of railway communication in that country. The shareholders of those lines had many difficulties to contend with, and part of the capital on which interest had now to be paid had been spent in overcoming them. In fairness he should also have stated that the Indian Government and the tax-payers reaped advantages from the

railways beyond the 3½ per cent. which they earned, and that at the same time those advantages occasioned a loss of profit to the railway proprietors; as also that some loss accrued to those railways that were under construction during the Mutiny.

The railways in India did not succeed turnpike roads and canals as in England, but often supplied the place of so-called 'roads' without bridges or metalling, consequently all skilled labour had to be taught. The skilled labour that had been taught by the guaranteed railways had become remunerative to the country, although the country might not at present have entirely recouped the money spent for their education.

Some of the railways were constructed at a considerable distance from the seaboard, causing not only excessive cost for transport, but a heavy item for delays in delivery. Mr. Tanner had seen a locomotive drawn by bullocks two hundred miles over an unmetalled road ankle-deep in dust; and convoys of carts thatched over in the jungle, waiting for the rains to cease before they could proceed on their journey, while platelayers and others who were in want of the materials, which those carts ought to have been conveying, were standing idle. Future railways in course of construction would not have to contend with such disadvantages, nor with the almost total want of skilled labour then experienced.

Those who knew India before the railways were in existence would recollect the relays of horses at every sixth mile, for the postal service of letters alone; and the relays of bullocks at every tenth mile for heavier parcels, newspapers, and such light merchandize as could afford the charge. The railway companies, by their contract, were obliged to carry the postal service for nothing, and even to provide vans—if not sorting vans. By the construction of the guaranteed railways the expense for the maintenance of horses, bullocks, carts, wagons, and the establishment previously necessary, had been saved for more than 5,000 miles.

The economy that accrued to Government by moving troops by rail, instead of by the costly establishment necessary for marching, had been already alluded to. The Author, to have drawn a fair comparison, might have shown what those savings amounted to, in order that they might have been added to the 3½ per cent. earned by the railways.

With regard to break of gauge, Mr. Tanner had lived long enough in India to know that an order by the Governor-General in Council was not to be argued against. But those persons who constituted the Governor-General in Council might after a time retire, and their successors might possibly not feel justified in

continuing the construction of the railways upon the scheme so strenuously advocated by the Author.

Mr. Tanner would give an instance. The Sutlej bridge was built in the most exposed part of the river, because the Governor-General in Council ordered it; the object being that it might be under the guns of the fort at Phillour, which was always to be garrisoned from an English regiment. The Governor-General in Council had changed before the first girder was in place, and a new order removed all the guns and the contents of the magazine to Ferozepore, 80 miles away, and the English troops were supplanted by one company of native infantry.

With regard to width of gauge, arguments had been adduced for and against the narrow gauge and the broad gauge—but had they been carried far enough? No one could gainsay that a narrow-gauge line could be made at less cost than a broad-gauge line, as far as the construction of the line went; but the saving was so little, that the extra expense for rolling-stock necessary for the narrow-gauge line to give equal carrying capacity would possibly counterbalance the saving effected.

Mr. Tanner had lately been engaged by Government to furnish two estimates for a single line of railway in one of the colonies. One on a gauge of 3 ft. 6 in., and another on a gauge of 4 ft. 8½ in. As there was no railway in the colony, there was no question of break of gauge, and the relative advantages of both gauges could be fairly weighed. The estimates were prepared from actual survey, and every minute detail was considered. The results might therefore be interesting.

The data started with, were as follows:—The engines were to be 6 wheeled, coupled; to weigh 18 tons, and to be suitable for a speed of 25 miles per hour. The load on the carriage wheels was to be 3 tons. The rails were to weigh 55 lbs. per yard. For the 3 ft. 6 in. gauge, the width of the bank was to be 14 ft. 6 in. at formation level. The width of the carriages was to be 6 ft. 4 in., and the length, 15 ft. For the 4 ft. 8½ in. gauge, the width of the bank was to be 15 ft. 9 in. at formation level. The width of the carriages was to be 8 ft. 6 in., and the length, 15 ft.

The result of the estimates gave as the cost per mile for the construction of the line alone:—

	£	s.	d.
On the 4 ft. 8½ in. gauge	5,139	13	9
„ 3 ft. 6 in. „	4,977	15	0
	£161	18	9

or a saving in construction of the line by adopting the 3 ft. 6 in. gauge of 3·17 per cent.

The cost per mile for construction, including stations, telegraph, and everything except rolling-stock, was as follows:—

	£	s.	d.
On the 4 ft. 8½ in. gauge	6,610	18	7
„ 3 ft. 6 in. „	6,445	8	3
.	£165	10	4

or a saving in favour of the 3 ft. 6 in. gauge of 2½ per cent.

Before comparing the rolling-stock of the two gauges a few words of explanation were necessary. Undoubtedly a narrow-gauge wagon, when carrying material such as stone, ballast, &c., could carry its load with less dead weight of wagon, and was therefore preferable and cheaper for mineral traffic; but for passengers the same floor area was required for both gauges. For light goods, such as loose cotton, the broader gauge gave better carrying capacity, for if there were no over bridges the load could be piled up higher, as well as wider. Floor area was therefore taken as the basis for comparison in the two estimates. The rolling-stock for the 4 ft. 8½ in. gauge amounted to £17,177, and that for the 3 ft. 6 in. gauge to £19,012; showing a saving of 10½ per cent. in favour of the 4 ft. 8½ in. gauge for equal carrying capacity. The total cost of the railway, with all accessories for traffic, gave a result in favour of the 3 ft. 6 in. gauge of 0·72 per cent.

The traffic estimated for was less than there would be in a very short time after the line was opened for traffic. He believed the rolling-stock would then require to be doubled. Under those circumstances the result would then be in favour of the 4 ft. 8½ in. gauge. All renewals for wear and tear would necessarily be in favour of the broader gauge. The railway referred to was for a special class of traffic, namely, that of carrying sugar hogsheads. A truck or wagon of the 3 ft. 6 in. gauge could only carry 3 hogsheads, while those of the 4 ft. 8½ in. gauge could carry 6 hogsheads. When this was taken into consideration, the result of the estimates was in favour of the 4 ft. 8½ in. gauge to the extent of 1·55 per cent. of the total cost.

Having spent fourteen years on the construction of Indian railways, he knew the disadvantages which those constructing them had to contend against. No fair comparison could be arrived at, by saying "the existing railways cost so much per mile; and our estimate is for so much a mile." A true comparison could only be

arrived at by taking the actual quantities of a length of line that had been executed, and by putting the same price against each item of work in the estimate for the proposed line. Surely it would be worth while to make such a calculation before embarking on a change of gauge for 10,000 miles. If such a comparison was made, he was certain the great saving anticipated by the Author would turn out to be almost visionary.[1]

Mr. W. T. Thornton, partly reading from copious notes, said that rather a heavy task had devolved upon him. He had to answer a large number of adverse speeches. To do so with any adequacy would require all the time that he could warrantably occupy, and at least all the strength which he possessed, so that he had better not waste any of either in prefatory remarks, but address himself at once to the business in hand.

It would be convenient to divide his opponents into two classes—those who had not met him with arguments, and those who had; and in the former category he should take the liberty of placing his excellent friend Mr. Andrew, and also Mr. G. P. Bidder. Both of those gentlemen seemed to have taken a hint from the well known story of a leading barrister, who, having risen in Court to answer the case for the prosecution, had a paper placed in his hand by his legal prompter, containing the words, "No case: abuse plaintiff's attorney." Changing plaintiff's for defendant's, this was what they had done. Mr. Andrew's abuse was, indeed, of a very mild description, and did not go much beyond likening Mr. Thornton to Rip Van Winkle, and suggesting that he must have been asleep for the last five-and-twenty years, and that he was therefore ignorant of the disasters with which the 'war of gauges' had been attended in this country. He must own that he could scarcely venture to pay off Mr. Andrew in kind. His excellent friend was very generally understood to be at all times pretty wide awake. Still, if it were possible to imagine him to have been caught napping, Mr. Thornton should really have thought

[1] As it had been stated by General Strachey (page 53) that, "until the Government of India announced its intention of carrying out narrow-gauge railways, as the only apparent means of obtaining cheap railways, none of the Engineers of the Indian lines—exclusive of the Oudh and Rohilkund Company and the Indian Tramway Company—suggested the construction of light or cheap lines, or admitted that they were possible." Mr. Tanner submitted a copy of a Report made by him to R. Saunders, Esq., Postmaster-General, Punjâb, dated December 6th, 1861, which Mr. Tanner requested might be printed in the Appendix. It would be seen that in that Report he did, so early as 1861, propose a light railway, and light engines of the normal Indian gauge.—*Vide* Appendix VI.

that on this occasion Mr. Andrew had been talking in his sleep. Mr. Thornton could not otherwise conjecture how a person of Mr. Andrew's acuteness could refer to the English battle of the gauges by way of thereby disparaging the narrow gauge. Surely he could not require to be reminded that in that battle it was the narrow gauge that won, and the broad gauge that was vanquished; so that, if any inference in regard to India was to be drawn from the case of England—not that the two cases were in reality at all analogous—that inference plainly was that, if in India the two gauges were ever pitted against each other, as they had been in England, the narrow gauge would be again victorious.

The personal remarks of Mr. Bidder were of a more decided character, intimating quite unequivocably that, in his opinion, Mr. Thornton was not an ordinary fool merely, but the very 'genius of folly.' He did not suppose that Mr. Bidder meant any harm by that. To talk in that style was very likely only a way he had—a sort of playful chaff. At any rate, Mr. Thorton had no desire to resent it. On the contrary, and on the principle of returning good for evil, he proposed before he had done to give Mr. Bidder, in exchange for his chaff, some solid, substantial grains to digest and ruminate upon.

Turning now to his argumentative opponents, Mr. Thornton was glad to observe that they had directed their chief assault against what had been previously admitted by him to be the key of his position, namely, the question of economy. True, if beaten there, he must acknowledge himself to be beaten all along the line, without one rallying point to return to. But he had no objection to be beaten, if he could be shown to deserve defeat. Contending as he was, not for victory—not for any foregone conclusion—but for truth, whatever the truth might be, he could not but be anxious that, if in error, his error might be exposed. Still, on the question whether he was beaten or not, he requested the Institution to suspend its judgment until they had heard him out.

In pressing the plea of economy, another person in his place might perhaps have engaged extensively in independent calculations, going in largely and learnedly for width of embankments, depth of ballast, sectional area of sleepers, and what not; and, by computing how much this or the other detail would cost on the broad gauge and on the narrow gauge, have shown how much less the aggregate cost would be on the latter than on the former. This was what a professional expert might have done, but which he did not attempt to do, for the very sufficient reason that he

could not have done it if he had tried, since, so far from pretending to be a professional expert, he frankly confessed himself to be an unprofessional ignoramus, or, as plain-spoken Mr. Bidder might say, a mere fool in technicalities. Besides, there would have been no use in doing it, even if Mr. Thornton had been able, for his calculations would infallibly have been disputed at every step, and at the end of them he should have been as far as ever from having established any premises in which the opposite side would have acquiesced. But without some premises, common to both sides, there could be no profitable discussion; so, since he could not hope that any data offered by himself would be accepted, he had no alternative but to accept those which had been put forward by his opponents.

He found that two Engineers of the very highest eminence—of the eminence implied by their having been selected by the Institution as its Presidents—had each of them carefully estimated the cost of railway construction under two different sets of conditions—or rather, he should say, of conditions similar in other respects, but different in this: that in the one case a 3 ft. 6 in. gauge, and in the other a 3 ft. gauge, was assumed. He alluded, of course, to Mr. Fowler and to Mr. Hawkshaw. Now there was more than one way in which Mr. Thornton might have dealt with those gentlemen's estimates. In both, the narrow gauge was credited with considerable, but different, amounts of saving—in Mr. Fowler's estimate, with £866 per mile; in Mr. Hawkshaw's estimate, with £760 per mile. Mr. Thornton might not unfairly have taken either of those amounts, and by making certain additions thereto, on grounds which he should presently advert to, have obtained a much greater total than he had actually claimed. That was what he might fairly have done, if his desire had been merely to make a fair show in figures. But that he did not do. Mr. Fowler and Mr. Hawkshaw differed not more as to the total amount of saving than as to the nature of the items on which saving was to be allowed; there being only four items admitted by both, namely, earthwork, bridgework, sleepers and ballast. Mr. Thornton began, therefore, by restricting himself to those four items; nor did he take even the highest of the totals which he found allowed upon those items, but only the mean between the two, and then to this mean he had added not the whole of what was admitted by his authorities on other items, for he rejected some of those other items altogether. He made additions in respect only of those further items which, although included by only one or other of his authorities, as the case might be, ought manifestly to have been included by both,

and could not have been omitted by either, except through inadvertence. By this means, and by allowing further for the superior cheapness of a mètre, or 3 ft. 3⅜ in., gauge, over the 3 ft. 6 in. gauge assumed by his authorities, he obtained £1,000 per mile as the average saving obtainable by the adoption for the Indian State railways of a light mètre gauge, instead of a light standard gauge. He said average saving: of course he agreed with Captain Tyler, that the actual saving would not be the same on all lines, but would vary with the character of the country and other circumstances, being sometimes more and sometimes less than the sum mentioned; but Captain Tyler would, he thought, admit, on reflection, that this was a reason not the less, but the more, for adopting an average in reference, not to any particular mètre-gauge line, but to all mètre-gauge lines in general.

While working out, as above, his total of £1,000 per mile, Mr. Thornton fancied, in his simplicity, that he was displaying an exemplary, an almost chivalrous, moderation; and was, therefore, proportionally disappointed—not to say disgusted—to find, when the matter came to be discussed, that his critics, with one accord, began to take exception to every one of the details of which that total was composed. Mr. Harrison, who led the charge at this point, with Mr. Bruce bringing up the rear, considered that he had been much too greedy in accepting at Mr. Hawkshaw's hands £10 per mile for land, seeing that Major Bonus, in his estimate for the Indus Valley line, had shown that 13*s.* 6*d.* per mile, or, as Mr. Bruce had it, more nearly 10*s.* per mile, was the maximum to be allowed. Major Bonus was an Indian Engineer officer of well-earned repute; and Mr. Harrison seemed to Mr. Thornton to exhibit a very just discrimination in preferring, on questions connected with Indian railway construction, the opinions of experienced Indian Engineers to those of the ablest members of the profession who had never visited the East. Mr. Harrison had, however, misunderstood Major Bonus's meaning to an extent not very remarkable in one who did not pretend to have any special knowledge of India, but somewhat curious in the case of Mr. Bruce, who ought to have known—and no doubt did know—a great deal about that country. When giving Rs. 27, or £2 14*s.*, as the price of an acre, and therefore 13*s.* 6*d.* as the price of a quarter of an acre, Major Bonus was speaking, not of India generally, but only of that territory—for the most part mere sandy desert—through which the Indus Valley railway would run. But Mr. Bruce, who had so skilfully conducted the Great Southern of India line from Trichinopoly to Negapatam, through the garden-like luxuriance of the Cauvery

Delta, ought not to require to be told that there was other soil in India besides sand, and that to judge of the value of the land that would have to be taken up for State railways in Northern Bengal, or the Dharwar cotton-fields, by its value between Mooltan and Hyderabad, was about as much to the purpose as it would be to suppose that the Metropolitan Railway Company and the Highland Railway Company got their land at the same rates per acre. It so happened that in certain instances—very exceptional ones it was true—the Government of India had to pay for the land presented by it to guaranteed railway companies no less than £725 per acre and £1,099 per acre, and this for areas of 141 acres and 61 acres respectively. After all, the figures objected to were not his figures, but those of Mr. Hawkshaw; but still, unless Mr. Harrison and Mr. Bruce could show better reason for questioning the correctness of Mr. Hawkshaw's allowance of £10 per mile for land, Mr. Thornton should not consider himself bound to surrender any part of it, although to part with the whole would not cause him any very great pang.

In regard to earthwork, Mr. Harrison practically agreed with Mr. Fowler—working out the sum for himself and producing a result of £36 15*s*. per mile, or within five shillings of Mr. Fowler's estimate of £37 per mile. Mr. Bruce, indeed, allowed only £33 per mile, differing therein both from Mr. Fowler and Mr. Harrison, and still more widely from Mr. Hawkshaw, who put down £100 per mile on the same account; so that, having here three to one against him, Mr. Thornton concluded that Mr. Bruce must give way. On the subject of bridges, Mr. Harrison admitted that he had no means of judging whether Mr. Hawkshaw's £50 per mile or Mr. Fowler's £83 per mile were right, but Mr. Harrison added, that he was disposed to err on the right side—to wit, that of superior strength, and therefore that he inclined to Mr. Hawkshaw. Now Mr. Thornton, feeling conscientious scruples against erring on either side, had gone midway between Mr. Fowler's estimate and Mr. Hawkshaw's estimate, and so had arrived at £66 per mile, and whoever bethought him of the proverb of his schoolboy days, "*In medio tutissimus ibis*," would probably consider that in so doing Mr. Thornton had selected the safest path. Mr. Bruce, at any rate, said nothing about bridgework; so it was to be supposed that his silence might be taken for acquiescence.

Mr. Bruce remarked, that he had put the bridges at £20 per mile, and given the details.

Mr. Thornton. In respect, however, to the far more important items of sleepers and of ballast there was universal disagreement.

Mr. Fowler on those accounts allowed £503 per mile; Mr. Hawkshaw, £200 per mile; Mr. Harrison—if Mr. Thornton rightly understood him—£257 per mile; Mr. Bruce begrudged £126 10*s*. per mile. These varying figures were the results of equally varying considerations, affecting sundry knotty points as to which Mr. Bruce questioned the sense of Mr. Fowler's decision in one instance, and denied it altogether in another. Such matters were too high for Mr. Thornton's comprehension; he did not profess to be able to attain to them, though he should have a word or two to say presently as to the way in which they had been treated.

Intermediately, however, he must touch upon two or three other matters. One was the saving on engineering and agency, respecting which Mr. Harrison took no objection to the rate of 17½ per cent. adopted by Mr. Fowler, neither did he deny that 17½ per cent. upon £497 came to £87, the exact sum given by Mr. Fowler and accepted by Mr. Thornton. Mr. Harrison proceeded, however, to observe that there were certain details, such as the setting out of the line, the preparation of plans and the estimate of all the works, the cost of which would be the same whether the gauge were broad or narrow, and upon the cost of which, therefore, the charge for engineering would likewise be the same in both cases. Now, no doubt upon all expenditure, common to both gauges, the same percentage charge for engineering would come to the same thing for both; but why the narrow gauge should not save the whole charge for engineering, in respect of an expenditure of £497 per mile, which was not common to both gauges but which applied to the broad gauge alone—why, as Mr. Harrison said, a large deduction should be made from the saving of £87 per mile claimed by Mr. Thornton on that account, Mr. Harrison did not explain; and what was still more in need of explanation was that Mr. Bruce, though professing to follow Mr. Harrison, was not contented with insisting on a large deduction, but required Mr. Thornton to leave out the saving altogether. The truth was that, instead of reducing, he ought greatly to have increased his claim for engineering. He ought really —according to Mr. Harrison—to take 17½ per cent., not merely on the £497 per mile aforesaid, but also on the sum total, amounting more nearly to £1,000 per mile of all the savings, other than those for engineering and agency, with which he had shown that the narrow gauge ought to be credited.

Then, at Mr. Hawkshaw's suggestion, he had taken for reduced cost of annual repairs of a narrow-gauge line £10 per mile, and had capitalised that annual saving at twenty years' purchase—

thereby obtaining a total on the item of £200 per mile. Mr. Harrison approved of the rate of £10 per mile, but both he and Mr. Bruce disapproved of its capitalisation on the ground of its not being an ingredient in first cost. But surely, supposing the price of a perpetual annuity of £10 to be £200, it made no difference whether £200 were paid down at once or £10 per annum were paid for ever afterwards, or, conversely, whether £10 per annum were saved for ever or £200 were saved at once. But if so, Mr. Hawkshaw was, Mr. Thornton submitted, perfectly right in that respect, and Mr. Harrison and Mr. Bruce were right only so far as they agreed with Mr. Hawkshaw.

Then came the vexed question of curves. Under this head Mr. Fowler had allowed nothing, because, as he said, in his own practice, in this and in other countries, he had never met with even a single case on which he should have adopted a different curve merely in consequence of gauge. Mr. Hawkshaw, however, even when estimating for a narrow-gauge extension of the Eastern Bengal railway through an almost level country, had allowed £200 per mile for the saving by use of sharper curves; though it was true, he now said, that he never expected so large a saving to be realised. Mr. Harrison also expressed a doubt whether this saving of £200 per mile could by any possibility be applied to the whole 10,000 miles of railway to be made in India; thus, by implication, intimating that Mr. Thornton had so applied it; while Mr. Bruce likewise left out the £200 per mile, which he, too, supposed to have been added by Mr. Thornton for curves, because he knew that "in ninety-nine cases out of one hundred in India, in the matter of such curves as they required, they would not save anything at all." Upon all which Mr. Thornton had first to remark, that not £200 per mile, but only £100 per mile, or only one half of what Mr. Hawkshaw, two years ago, calculated might be saved, by means of sharp curves, even in the dead level of Northern Bengal, was added by Mr. Thornton as the probable average on 10,000 miles of railway, a considerable portion of which would traverse exceedingly hilly and even mountainous country.

He would now mention one or two facts, which might perhaps suggest that Mr. Harrison and Mr. Bruce had been somewhat hasty, in deciding that there was no difference as to curves between broad gauge and narrow gauge, and that Mr. Hawkshaw had been equally hasty in abandoning the more correct opinion on the subject which he until lately entertained. Mr. Thornton supposed he might assume that on none of the existing broad-gauge lines of India were the curves anywhere sharper than on the Thull and

Bhore Ghaut sections of the Great Indian Peninsula line, where the sharpest curves were only 15 chains radius—of which, moreover, there were but 2, all the rest being of at least 20 chains radius—and where, by-the-way, there were more than 2½ miles of tunneling; and the average cost of construction was between £48,000 per mile and £49,000 per mile. Now on the Punjâb Northern railway, there was a section 70 miles in length, between Jhelum and Rawal Pindi, described as "wild, hilly, and broken to an extent rendering a railway a most formidable undertaking." On that section, while as yet it was supposed that the standard, or 5 ft. 6 in., gauge was to be adopted, the Engineer who surveyed the section, assuming a radius of 20 chains as his minimum, reported that extensive deviations of 22¾ miles in all would have to be made. The same Engineer, however, having been thereupon informed that the mètre gauge, and not the standard gauge was to be adopted, and that his ruling curve was to be 4½ chains radius, made a new survey, and then reported that it had been found practicable to reduce the 22¾ miles of deviations previously deemed necessary to little more than 2½ miles; and that this had been done without going below a 5 chains radius, of which, however, there were 19 curves. What had here been the consequent saving Mr. Thornton would leave others to calculate; but no doubt it must have been something very considerable indeed; and in all probability still more considerable savings of the same kind had been, or would be, found practicable on the Ghaut sections of the Indore and Carwar lines, where much wider scope for sharp curvilineation ought, apparently, to be afforded than on the worst portions of the Punjâb northern line. He might however mention that on the Carwar line there was, in one place, an unbroken incline of 1 in 40, which extended for nearly 4 miles, with curves of 5 chains radius; those curves of course implying an immense saving in the heavy work, which the standard-gauge curves of 15 chains radius, or 20 chains radius would have necessitated. It was quite clear, then, that on Indian mètre-gauge lines generally there must be some sensible average saving per mile by reason of curves. Very likely that saving might be a good deal below the £200 per mile, at which it had been hypothetically put by Mr. Hawkshaw, who, however, in suggesting that amount, was clearly much nearer the truth than Mr. Harrison and Mr. Bruce, who put it at nothing. Whether Mr. Thornton, in putting it at £100 per mile, or as nearly as possible half-way between nothing per mile and £200 per mile, was not likely to be nearest of all to the truth was a question on which modesty forbade him to decide.

In answer to a question by Mr. Harrison as to the authority upon which he had stated that 20 chains radius was fixed as the minimum, Mr. Thornton explained that it had not really been so fixed, but that the Engineer thought it was. On the Bhore Ghaut, of the Great Indian Peninsula railway, the sharpest curve was 15 chains radius, and there were only two such, none of the others being below 20 chains radius.

Returning to the items of sleepers and ballast, what hopeless discord of opinion was there exhibited! Mr. Hawkshaw differing widely from Mr. Fowler, and Mr. Harrison and Mr. Bruce disagreeing between themselves in all else, and agreeing only in pooh-poohing Mr. Fowler, and by implication Mr. Hawkshaw also. Well, very likely Mr. Fowler, if he had been present, might in his turn have pooh-poohed Mr. Harrison and Mr. Bruce. But what construction was an impartial outsider to place on such universal pooh-poohing—what but that in all probability there was on the whole very good cause for it? Of the four eminent Engineers concerned in it, every one was completely at variance with all the rest. Only one, therefore, out of the four could possibly be in the right, while the other three must necessarily have been in the wrong; and the odds were that all four were in the wrong, since there were no three amongst them who did not pronounce the fourth to be so. At any rate, eminent as all four authorities were—'engineering giants,' as Mr. Danvers, without much exaggeration, had styled them—no one of them could prudently be here accepted as a guide, except in so far as his dicta were borne out by fact. But of fact, unfortunately, there was very little available; Mr. Bruce alone having hitherto attempted to adduce any. The latter gentleman, however, having obtained the estimates for 216 miles of mètre-gauge railway, described as in process of construction in the south of India, had examined those estimates to see what would be the extra cost of making the railway on the broad gauge, and he had calculated that the extra cost per mile would be £27 10*s.* for ballast and £99 for sleepers. This he said was not an idea but a fact. How was it a fact? The only fact apparent was, not that the thing was so, but that he had calculated that it would be so. But might it not possibly be equally the fact that he had made a miscalculation? By reducing to a minimum the saving on a variety of other items, as well as sleepers and ballast, and by ignoring some important items altogether, he made out that the difference of cost, between the mètre gauge and the standard gauge in one special locality, would be under £200 per mile, and then he assumed that the same would be the total average saving all over

India. But to the one single, so-styled, fact appealed to by him in support of that view, Mr. Thornton was in a position to oppose a counter-fact of the same description, but much stronger of its kind. In another part of India, namely, in the Punjâb, the difference of cost between the mètre gauge and the standard gauge for the lines between Peshawur and Lahore, and between Mooltan and Kotree, had quite recently been estimated, not by Engineers in England, many thousands of miles off, but by Engineers on the spot, and by Engineers, too, whose predilections were by no means in favour of the mètre gauge in that quarter, and the result had been to show that the standard gauge would cost £721,000 more than the mètre gauge. But £721,000, divided by 773 miles—the aggregate length of the lines estimated for—gave, not Mr. Bruce's £200 per mile, but £930 per mile; just £70 per mile less than the £1,000 per mile claimed by Mr. Thornton. But Mr. Bruce's total being thus presumably so very far below the reality, the separate items, or some of them, composing that total must be presumed to be equally erroneous. Either he must have materially understated the savings on sleepers and on ballast, or some others of the savings which he had allowed, or there must be some items over and above those of engineering, agency, maintenance, renewal and sharp curves, already specially adverted to, which he had altogether omitted to take into account. Whether his faults of commission or of omission were the more important was not for Mr. Thornton to say. It was a matter for theoretical investigaton, on which he should not venture; but setting theory on one side, one thing to which he desired particularly to invite attention was that, so far as facts could be brought to bear upon the matter, those facts were much more nearly corroborative of his total saving per mile of £1,000, than of Mr. Fowler's £860, Mr. Hawkshaw's £760, Mr. Bidder's £600- Mr. Harrison's £400, or Mr. Bruce's £200; and further, that, though Mr. Thornton's figures were nearest of all to the mark, Mr. Fowler's were the second nearest.

In answer to a question, Mr. Thornton said the weight of the rails was assumed to be 40 lbs. per yard in all cases.

Considering his fundamental position to be thus far sustained by fact, he did not think he should risk much by asking the Meeting to decide whether that position had hitherto been damaged. Considering how numerous, how able, and how outspoken had been its critics, he might fairly take for granted that pretty nearly all that could be said against it had already been said; but would any one assert that it had been in the slightest degree shaken? Would it, at any rate, be said that adequate reason—or, rather, the slightest shadow of reason

—had been shown, why the figures of any one of his critics should be substituted for his? If it was thought there had, let him ask, whose?—which of the many utterly irreconcilable totals did the Meeting prefer? Was it Mr. Bruce's, or Mr. Harrison's, or Mr. Bidder's, or Mr. Hawkshaw's, or Mr. Fowler's? Probably time might be necessary to determine. But while the mind of the Meeting was being made up, it could not be denied that he was entitled to adhere to his saving of £10,000 per mile or of £10,000,000 on 10,000 miles; nor, what was infinitely more to the purpose, that the Government of India was likewise warranted in provisionally adopting and acting upon those figures.

Here, as to the general question, the defence of the Indian Government might be safely rested. Having reason to believe that to construct the State railways on the standard gauge instead of on the mètre gauge would involve an additional expenditure of £10,000,000, it might irreproachably decide not to make State railways at all, rather than make them at such a cost. It might irreproachably consider that it had done enough in taxing its subjects to the extent of £1,600,000 per annum, for the 5,000 miles of railway already constructed, without, by constructing 10,000 miles more, increasing that load of taxation to £2,100,000 per annum. Many gentlemen present might think that, in so deciding, Government would decide wrongly. Some gentlemen present had distinctly intimated that the Indian tax-payer—"this very pitiable and most interesting tax-payer," as in not quite the best possible taste he had been designated—should be disregarded in this matter. That, however, was a question which, as even those gentlemen would probably admit, was one rather for the statesman than the engineer, and one of which men with the statesmanlike qualities and experience of the Duke of Argyll, Lords Lawrence, Mayo and Sandhurst, the late Sir Henry Durand, Sir Henry Maine and Sir John Strachey were, on the whole, likely to be more competent to judge than the purely professional tribunal to which Mr. Lee Smith would refer it, even though that tribunal were composed of the 'élite' of the distinguished men who were now sitting, or had hitherto sat, in the President's chair, or around the council-table of the Institution he was addressing.

Even though it were established that, unless made of the standard gauge, by an outlay upon them of an extra £10,000,000, the projected State railways would not adequately answer their purpose, that might be a very good reason for making no State railways at all; but it would be no reason for making the State railways of the standard gauge. The same remark held good of a break

of gauge. That a break of gauge was, abstractedly, a great evil, was not denied. That it must sensibly impair the utility of most of the projected State lines, was not denied. But even though, instead of merely impairing, it altogether destroyed their utility, it would not be a reason for making them of standard gauge. In the actual circumstances of the case, the choice, as he had said in the Paper, was not between a broad gauge and a narrow gauge, but between a narrow gauge and no gauge—and no railways.

Of course, however, he was not admitting that mètre-gauge lines would not, for all carrying purposes—in other words, for all purposes whatever—answer perfectly in India. Scarcely any one who had spoken in the course of the discussion denied it—certainly not Mr. Bruce nor Mr. Harrison; while General Strachey had stated how the average daily traffic of the most heavily worked standard gauge line in India—the East Indian line—could be carried on the mètre gauge by 12 trains each way, of 17 vehicles each, the vehicles, too, being not more than half filled. True, as Captain Tyler had objected, a railway should be adapted not for average traffic, but for maximum traffic; but then, Mr. Thornton would ask Captain Tyler how soon he expected the maximum traffic of the best of the projected State lines to exceed the average traffic of the East Indian line, considering how comparatively poor and thinly peopled were the territories proposed to be traversed by the State lines?

Mr. Thornton had already said, that break of gauge had no proper connection with the larger of the two great subjects under consideration, namely, that of the applicability of the mètre gauge for State lines generally. Nevertheless, it would be useful to correct some exaggerated notions of the disadvantages of the break of gauge which had been deduced from English experience. Previously, however, he was bound to make the 'amende honorable' by correcting a mistake of his own. He had been very properly taken to task by Mr. Hawkshaw for assuming 4*d.* per ton to be pretty generally considered to be the maximum representative, in cash, of the commercial ill effects of a break of gauge; for although in the report of General Strachey, Colonel Dickens, and Mr. Rendel, he found that rate given as a maximum, Mr. Hawkshaw, in his report, said that the rate per ton was variously reckoned at 4*d.*, 8*d.*, and 1*s.* Mr. Thornton acknowledged his inadvertence, and humbly apologised for it, though he would presently show it to be of no consequence, in respect to the present issue. Some persons present would not, however, be content with his crying 'peccavi' to the extent merely of confessing that, whether 4*d.* per

ton was, or was not, the maximum expense incident to break of gauge, it was not in England admitted to be so. One gentleman, if he recollected rightly, declared the evils of a break of gauge to be simply infinite; another, that they could not be estimated in money; while a third demanded whether, if *4d.* per ton—or anything like *4d.* per ton—were their pecuniary equivalent, it was likely that the English broad-gauge companies would, for the sake of saving such an insignificant expense, have gone to the enormous expense of relaying most of their lines on the narrow gauge? Well, he was quite sure they would not. They would not have cared a jot, even though the cost per ton had been *4s.*, or £4, for that matter, instead of *4d.*, provided the traffic would have consented to pay that rate for translading. What really actuated the broad-gauge companies was not the expense of translading, but the impossibility of competing with the narrow-gauge companies, which had no break of gauge, and no translading to charge extra for; and to render such competition impossible, not *4d.* per ton, but one farthing per ton would have sufficed. A farthing per ton would suffice to turn the scale in the eyes of traders, who were considering by which of two rival lines they would send their goods. But in India there was no idea of letting the two gauges come into competition. There were not to be there any standard-gauge lines and mètre-gauge lines running from the same point in the same direction. Goods brought by railway to any station, at which the break of gauge occurred, and intended to go on by railway, would have no choice but Hobson's. They must either proceed by the mètre gauge or by the standard gauge, as the case might be, or they could not go on by railway at all, for there would be but one gauge to go on by. The only question for the trader would be whether, rather than pay the extra railway charge for break of gauge, he would not send on his goods by road or river, and there could not be much doubt in which way any trader in his senses would answer that question. At any rate, the good sense of the Meeting would at once decide that the extra railway charge for translading would certainly not be so high as what the trader would have to pay for transferring his goods from a railway train to ordinary carts, or boats, or steamers.

Were there, however, no means of ascertaining with some approach to precision what the extra railway charge consequent on a break of gauge would actually be, in India? Captain Galton apparently considered that there was some mystic connection between it and the price of the goods affected, and on that ground he had contended that, instead of an amount of £850—at which, at

the rate of *4d.* per ton, Mr. Thornton had reckoned the charge for translading 51,000 tons and upwards of salt and sundries at Lahore —the amount should be at least £16,000. He really wondered that Captain Galton was not himself taken aback by his own figures. Sixteen thousand pounds sterling—merely for removing about three times that number of tons of salt from one set of trucks to another set of trucks a few yards off! It was very good natured of Captain Galton to devise such freaks of fancy, for the amusement of the Meeting; but life was too short to allow of their being seriously discussed. The Meeting could have a good laugh at them, and then he would pass on. Only if Captain Galton should interpose, to the effect that he was referring not to the mere cost of handling goods, which was the only thing Mr. Thornton was speaking of, but to the damage and injury to goods, incidental to a break of gauge, repeating, on the authority of his salt-manufacturing friend in the Midland districts, that one shilling's-worth of every thirty shillings'-worth of salt transladen was spoilt in consequence, his rejoinder would stand thus. What severer satire could possibly be passed on English railway management? On Indian railways—those at least which would belong to Government—it was to be hoped things would be better managed. Proverbially inefficient as all Government executive arrangements were, Government did not despair of being able to devise some means of getting goods transferred from one train to another train close by, without one bale or sack or ton in every thirty being spoilt or lost or plundered during the operation.

Descending, however, from these imaginative flights to the solid ground of fact, the Meeting had been told by Mr. Rendel, Consulting Engineer of the East Indian railway, that on the Nulhatti offshoot from that line the actual contract charge for translading from the broad gauge to the narrow gauge, or 'vice versâ,' was only *3d.* per ton; and to this important piece of testimony Mr. Thornton was able to add another, equally important and unimpeachable, derived from another Indian railway—the Eastern Bengal—of which Mr. Hawkshaw was Consulting Engineer. To and from Kooshtee, the present terminus of that line on the river Ganges, a great deal of traffic was carried by a steam flotilla belonging to the company, that portion of traffic, of course, breaking bulk at Kooshtee. Now, in a report, dated in September, 1870, by Mr. Prestage, the Railway Company's agent in India, it was stated that the quantity of goods breaking bulk being taken at 145,620 tons, the mere handling of them, according to the actual rates paid at Kooshtee, would amount to 30,580 rupees, or £3,058. Dividing

this sum by the tonnage, the quotient would be a minute fraction over 5*d.* per ton; and this it would be observed was for translading, not from railway train to railway train, but from river to rail, or rail to river; obviously a much more difficult and troublesome operation. Wherefore, whatever were the extra charge for a break of gauge per ton in England, whether 4*d.*, 8*d.*, or 1*s.*, or 6*s.*, it was clear that, in taking its maximum in India to be 4*d.* per ton, just half way between 3*d.* and 5*d.*, he had, instead of understating, rather overstated it.

This, however, being assumed to be the average rate, let it be inquired what it would amount to on the whole 10,000 miles of projected State railways—and here he would interpose that these 10,000 miles were not a mere myth; he could assure Mr. Berkley he could show him projected lines which, taken together, would make up 10,000 miles.* On the 5,000 miles, almost entirely broad gauge and guaranteed, already open for traffic, the total quantity of goods of all descriptions carried in the year 1871 was, according to Mr. Danver's official report, 3,330,000 tons. That was the whole traffic of every description carried by all the guaranteed railways in India. Now no one could reasonably expect that, on the 10,000 miles of State railways, the aggregate annual traffic would for years to come amount to that, still less that it would become twice that traffic. Nevertheless, what no one could expect, he would, for the sake of argument, suppose. He would suppose that, not at some distant date, but immediately on their being all opened, the aggregate annual traffic would be not 3,330,000 tons, but 6,600,000 tons. Again, no one could expect that nearly so little as one-half of the aggregate traffic would be local traffic—that was, traffic not passing from the mètre-gauge lines—or therefore, that nearly so much as one-half would be through traffic that would have to break gauge on exchanging to or from the standard gauge. Yet, once more—what could not be expected—he would, for argument's sake, suppose,

---

* *Foot-note added by* Mr. Thornton, *on the 7th of May,* 1873.

I am sorry to find myself, on further inquiry, obliged to admit that this was a considerable over-statement. The Indian Government did certainly in March, 1869, represent to the Secretary of State that about 10,000 miles were then wanting, in addition to the 5,000 miles already constructed or in process of construction, to provide India with a complete network of railways, but of those 10,000 miles, not more than 3,000 have as yet been actually marked out.—W. T. T.

R

namely, that not less than 3,300,000 tons would have to break gauge. Yet even under these almost impossible suppositions, £50,000 per annum would, at the rate of *4d.* per ton, be the utmost expense consequent on break of gauge. But on the £10,000,000 which he had shown to be the probable saving consequent on the adoption of the mètre gauge, the interest at 5 per cent. was £500,000. On the £6,000,000 which, according to Mr. Bidder, would be saved, it would be £300,000. On Mr. Harrison's £4,000,000, it would be £200,000. Nay, even on Mr. Bruce's £2,000,000, which nobody but himself, not even Mr. Harrison, considered more than one-half the proper amount, it would be £100,000. What doubt, then, that the Indian Government were right in not sacrificing the equivalent of, at the very least, £100,000, and almost certainly £500,000, for the sake of saving an expense of only £50,000 per annum? If there were any doubt, there was one consideration that ought to remove it. The very lowest of these estimates, even Mr. Bruce's paltry £2,000,000, put out at interest, would in 4 years or 5 years accumulate to the amount requisite, at £500 per mile, for taking up and relaying, on the mètre gauge, the whole existing 5,000 miles of guaranteed lines, should the break of gauge between them and the State lines ever turn out to be a serious disadvantage. And if it would thus happen, even with Mr. Bruce's £2,000,000, how would it be with Mr. Harrison's £4,000,000, or Mr. Bidder's £6,000,000, or with Mr. Thornton's £10,000,000? Why, according as one or another of those turned out to be the nearest approximation to the real amount, the present broad-gauge lines might all be relaid on the mètre gauge, and the break of gauge be got rid of, and Government would nevertheless find itself with £2,000,000, £4,000,000, or £8,000,000 more in pocket than it would have done, if it had avoided break of gauge by making its State lines on the standard gauge.

Thus much for the general question; to which succeeded the special one, whether there were in the Punjâb any circumstances so exceptional as to render the considerations, hitherto set forth, inapplicable to that province. Upon this point, his most prominent antagonist was his ingenious friend Mr. Lee Smith, who began by intimating that he had devoted much study to the subject, and could give a good deal of information regarding it, not generally known, and who certainly did treat the Meeting to one or two novelties. Any shareholders in the East Indian railway, who happened to be present, must have pricked up their ears on being told by him that a section of 81¼ miles in length of their line, of which he had responsible charge, was constructed for £6,160 per mile; and

44 miles for exactly £5,370 per mile. Knowing, as they did but too well, that whatever their railway might have cost, they at all events had been charged for it more than £20,000 per mile, they might naturally be curious to know what had become of the odd £14,000 per mile, and they had better perhaps call upon their Engineers, or whoever else was responsible, to explain. Some others of the details entered into by Mr. Lee Smith were considerably more recondite than apposite. He blamed the Government for resolving to utilize as much as possible for railway purposes the trunk road already constructed at very great expense between Lahore and Peshawur, notwithstanding that he had recommended quite a different line, which would have left this trunk road unused and useless, and have converted its cost into so much money thrown away. Again, he blamed Government for deciding that part of the Indus Valley line should be on the right bank of the Indus, notwithstanding that he, with curious infelicity, stoutly maintained that the right bank was the wrong one. Further, he proved to demonstration that if Mr. Thornton's figures or Mr. Fowler's figures were compared, not with their own figures, but with General Strachey's figures or somebody else's figures, the comparison would not bring out the same results as if it had been made with their own figures. To show how little all this had to do with the position taken up in the Paper, it might have sufficed simply to repeat what that position was. Mr. Thornton need not, however, do even that. Most of what he might call Mr. Lee Smith's financial criticisms might be still more summarily disposed of. Within the last few days there had been received from the Government of India a despatch, in reply to one from the Secretary of State, forwarding for report certain representations of Mr. Lee Smith, to the effect that Government, by letting an anonymous Contractor, whom he knew of, make the Punjâb lines on the broad gauge instead of on the narrow gauge, would absolutely save money. The following were extracts from that despatch:—

"In regard to the real cost of changing now from the metre to the $5\frac{1}{2}$ feet gauge, we have received the following report from our Consulting Engineer for State railways, which is concurred in by our other professional advisers:—

"I have carefully gone into the question of comparative cost of the two gauges, and, taking into consideration the work already done, the results are given in round numbers as follows:—

"Amount by which a railway with an unbroken gauge of 5 feet 6 inches will exceed the cost of a metre gauge line, from Kurrachee to Peshawur."

The comparison was made with both 60 lbs. rails and 40 lbs. rails; but as it was now admitted on all hands that the yet unexecuted portions of the Punjâb system must have light rails, Mr. Thornton would trouble the Meeting with only that portion of the estimate relating to the 40 lbs. rails:—

Railway.	With 60 lb. rails.	With 40 lb. rails.
	£	£
Indus Valley railway	1,021,900	531,900
Lahore to Jhelum	376,900	135,700
Jhelum to Peshawur	757,400	494,000
Total	2,156,200	1,161,600
Deduction for third rail and additional rolling-stock	620,000[1]	440,000
Net Excess	£1,536,200	721,600

"The structures with the 60 lb. rails are intended to suffice for ordinary broad-gauge engines, as well as for carriage and wagon stock; those with the 40 lb. rails are intended to suffice for broad gauge carriage and wagon stock only.

"The estimate includes the entire loss which would accrue from the abandonment of works on the lines in progress, but presumes that all rails, girders, &c., suited for the narrow gauge, can be made use of elsewhere in India.

"We believe your Grace may rely on this estimate as giving as nearly as possible, without entering upon surveys and very minute calculations, the probable cost of altering the gauge of these lines at the present time. It will be seen that the result differs entirely from that arrived at by Mr. Lee Smith, and that the figures given do not (for the reasons above explained) admit of detailed comparison."

In the Paper, the total net saving claimed for the Punjâb system was £532,823, but it had now been ascertained to be at least £720,000, or nearly £200,000 more than Mr. Thornton had reckoned upon. He

[1] "This is the estimated cost of laying a third rail on the lines between Kurrachee and Kotree, and between Lahore and Mooltan, and of providing additional rolling-stock for military emergencies. If the broad gauge were adopted with 60 lb. rails, the whole estimated sum of £620,000 would be deducted. If the rail be of 40 lbs. weight, the heavy engines of the guaranteed lines could not travel on the rails, and the portion of the deduction calculated for the engines could not be made. A reduced reduction is therefore made for that case."

might naturally be expected to be well content with so large and unexpected an addition to his original claim, but he was not so. His appetite had, he supposed, grown by being fed. The saving estimated by the Government Engineers had been reduced from £1,161,000 to £720,000 by deductions for third rails and additional rolling-stock, but the greater part of those deductions he believed he could show to be quite uncalled for. In the Paper he had contended that no additional rolling-stock would be required by reason of the mètre gauge on the Lahore-Peshawur line; since, whether the gauge were the standard gauge or the mètre gauge, to whatever quantity of rolling-stock were needed for ordinary traffic, addition would equally have to be made for extraordinary emergencies; and no one had ventured to impugn so palpable a truism. Even Mr. Lee Smith had shrunk from running his head against that post. Mr. Thornton had further contended that, on the Lahore-Mooltan line, the aggregate of rolling-stock would not need to be augmented in consequence of the creation there of a mixed gauge; because, in his opinion, to whatever extent the mètre-gauge rolling-stock was provided, the broad-gauge stock would become superfluous and might be dispensed with. But here, he confessed, he was fairly caught tripping by Mr. Harrison, who, with no more than just severity, remarked that, as the merest tyro in railway management ought to know, more rolling-stock would practically be sure to be wanted on a railway, if the traffic were divided between trains of two different gauges instead of being all despatched by vehicles of one and the same gauge. Even Mr. Thornton, who would be too much honoured by being termed a tyro, must own that he ought not to have overlooked a point so obvious, and taking shame to himself accordingly for the oversight, would now do his best to repair it. Since in the circumstances supposed, some more rolling-stock would plainly be required, let it be inquired, how much more? The Lahore-Mooltan line having, let it be supposed, become a mixed gauge, and been adequately supplied with mètre-gauge stock, the quantity of broad-gauge stock required, in addition, would of course depend upon the proportion of traffic that would be required to be despatched by broad gauge. Now the traffic that must necessarily, or rather that could preferably, be so sent, was plainly only so much as having either originated in, or being destined for, places eastward of Lahore would have to pass through Lahore. For all the rest of the traffic, for all, that both originated in, and was destined for, places between Lahore and Kurrachee, the mètre gauge would serve just as well, and for much of it very much better than the broad gauge—just as well for all traffic both originating in,

and stopping at, places north of Mooltan; very much better for all traffic either originating in, or bound for, places south of Mooltan, and which if sent by the broad gauge would have to break gauge at Mooltan. Very well then, the traffic requiring to be sent by broad gauge would be such only as required to pass through Lahore. But, although there had for some time been continuous broad-gauge railway communication between Mooltan and the whole region eastward of Lahore, the portion of the annual goods traffic of the Lahore-Mooltan section passing in either direction through Lahore was at present only 12,930 tons; neither, indeed, could it be estimated at nearly so much, except upon the highly improbable supposition that the whole of the existing traffic between the Punjâb and the territory to the eastward was carried by rail, and none of it by river or common road. Taking it, however, at 12,930 tons, that was the whole amount of traffic on the Lahore-Mooltan line, for which, in order to save it from the necessity of breaking gauge, it would be necessary to provide standard-gauge rolling-stock. But 12,930 tons distributed over 313 working days gave an average of only 41 tons a day, or about 4 standard-gauge-wagon loads. Of the whole existing quantity of such stock, therefore, only 6 wagons, or say at the utmost 12 wagons, together with proportionate engine power, would need to be reserved; all the rest might be replaced with mètre gauge stock, and be disposed of by sale to some other broad-gauge railways; the guaranteeing Government which would have to bear any loss, consequent on such sale, being to a great extent, if not completely, indemnified by the corresponding gain obtained by the purchasing railway.

After all, then, it seemed that, though theoretically wrong with regard to the Lahore-Mooltan section, he was practically all but, and should have been quite, right, if, instead of saying that neither for it, nor for the Lahore-Peshawur line, need one penny of expense be incurred for extra rolling-stock, he had said that some £5,000 or £6,000 would be the utmost expense needful on that account. All, therefore, beyond this mere trifle that the Government Engineers had deducted from the first total of savings in their recent estimate, ought now to be restored, in order to bring back that total to its proper amount. But that was not all. If, when, by the laying of a third rail, the Lahore-Mooltan line had become mixed gauge, there would be next to no traffic to travel upon the broad gauge, what use was there in laying a third rail? Why not, instead, take up the permanent way and relay it on the mètre gauge, thereby saving the difference of cost between the two operations, which he had seen estimated somewhere at £783 per mile

or at £167,462 for 214 miles, and obtaining the latter sum as a further additional saving? Among other recommendations of this plan, was that they should thereby get rid of what Mr. Lee Smith called the "third leg to a pair of breeches." The double gauge proposed by Mr. Fowler for the section between Lahore and Mooltan ought really to have been likened to a pair of breeches with two legs. The problem, according to Mr. Lee Smith, would be to divide at Mooltan, between the broad gauge and the narrow gauge, the goods brought thither from the southward, by a single narrow-gauge line; and this problem he pronounced insoluble by any ordinary station-master. It did not occur to him that the problem might have been solved beforehand by the station-masters at places south of Mooltan. He took it for granted that the station-masters would be too stupid to think of putting goods intended to go beyond Lahore into one set of wagons, and the goods intended to stop short of Lahore into another set. Truly, if the generality of station-masters, on the existing Indian railways, were no greater geniuses than those with whom he seemed to have come in contact, it was perhaps a good thing that their traffic had hitherto been so much less than was originally hoped for. With anything like the English average of traffic they would apparently have been at their wits' end.

To return—enough had been said to show that, so far from half a million, or three-quarters of a million pounds sterling being an over-statement, the real saving consequent on the adoption of the mètre gauge for the whole Punjâb system was not unlikely to be a good deal over a million pounds sterling, nearer perhaps to the figures of General Strachey than to those of any one else. Little, then, remained but to determine whether, or how far, this pecuniary saving would be counterbalanced by the evils attendant on a break of gauge. Here, at the outset, Mr. Thornton must take leave to remark that much of what had been said by the Astronomer-Royal, by Mr. Allport, and others as to the commercial evils of the break of gauge, although perhaps perfectly just was also perfectly irrelevant. Neither, Mr. Thornton must own, however convincing it might have seemed to others, was he always convinced by it. When, for instance, Mr. Allport imagined the case of a narrow-gauge truck load of 5 tons or 6 tons of goods having to be transferred to a broad-gauge truck, capable of carrying 10 tons, it occurred to Mr. Thornton that for the waste of space and increase of dead weight that would then take place, there might not impossibly be full compensation when, the circumstances being reversed, the freight of an only half filled broad-gauge

truck was transferred to a narrow-gauge truck, which it would completely fill. Again, when Mr. Allport spoke of eight millions or nine millions of tons of coal being annually carried on the English Midland line, Mr. Thornton did not fail tacitly to admit that if there were the slightest chance of that quantity of coal, or salt, or anything else, having to break gauge at Lahore, it would be well worth while to spend not one million, but two millions, or three millions extra, in order to prevent the indescribable block thereupon inevitable. But at Lahore, at which place alone, if the section between it and Mooltan was relaid, as he had suggested, there would be a break of gauge, there would, as could be shown by appeal to indisputable facts, be no question of eight million tons, or nine million tons, but only, at the very outside, of some sixty thousand tons. He found, indeed, with reference to what he had said on that point, that a deservedly-esteemed journal, "Allen's Indian Mail," remarked that he made no allowance for the certain growth of traffic from the Punjâb to various parts of India as new lines of railway were opened out. But he begged to say that, so far from making no allowance, he allowed very nearly a four-fold increase on that account. He found, speaking of the country between Lahore and Peshawur, the total traffic passing annually through Lahore from either east to west, or west to east, to be only 526 tons, exclusive of salt, or 13,526 tons, inclusive of salt; and he assumed it, immediately after the completion of the railways, to spring up at once to 51,052 tons, inclusive of salt. He did not really believe it would become anything of the kind. That continuous railway communication from Peshawur to Kurrachee would immensely develop both the internal traffic of the Punjâb, and also its external trade through Kurrachee, and with the country west of the Indus, he had no manner of doubt, and he heartily congratulated Mr. Andrew on the brilliant future in store for those portions of that continuous line of which he was Chairman, when his sections, relaid on the mètre gauge at the charge of Government, and, therefore, with their working expenses materially reduced, should at length receive free, gratis, and for nothing, abundant accessions of commerce, brought to them from both directions by the no-longer missing link. Whatever other people might think or feel, the shareholders in Mr. Andrew's Company, at all events, would have reason to congratulate themselves that sections sure to be unremunerative themselves, but calculated to render the Company's sections remunerative, would have been made at the cost, not of the Company but of the public. But that very little, if any, of this new trade would pass through

Lahore was as certain as that the trade itself would arise. Why should it? Of what description was the existing through traffic at Lahore? On examining the statistical tables, to which he had referred, it would be found that of its paltry total of 526 tons, exclusive of salt, passing towards Peshawur, or 'vice versâ,' a good deal more than one-half consisted of imports from Calcutta to Peshawur, Rawal Pindi, and Dera Ismail Khan, no doubt chiefly European supplies for the use of the European inhabitants of those outposts. But of mutual interchange of indigenous products between the territories east and west of the rivers Ravee and Sutlej there was almost nothing, nor so long as the industry of the territories remained chiefly agricultural was there likely to be any change; for to send farm produce of almost any kind, in either direction, from one side to the other, would be like sending coals to Newcastle. Salt had hitherto been the only article interchanged to any extent, and even of that the interchange was more likely to diminish, than to increase when the State railways in progress should freely circulate the salt of the Jhelum mines throughout the Punjâb, and the salt of the Sambhur Lake throughout Rajpootana.

It thus turned out that, on the supposition of there continuing to be broad-gauge communication from Mooltan through Lahore, he was fully warranted in taking £850 per annum to be the full pecuniary equivalent of the commercial evils of the break of gauge, although if, as he had suggested, the Lahore-Mooltan section was made on the metre gauge, 12,930 fourpences, or £210 would have to be added, raising the £850 per annum to £1,060 per annum. In regard to the strategic evils, he had had the satisfaction of hearing all he said borne out, and more than borne out, by that highest of all authorities, Lord Lawrence, who had shown the Meeting that, so far as military movements were concerned, it would practically matter little if there were three breaks of gauge, or four breaks of gauge. In fact, however, there need be but one break of gauge, namely, at Lahore. Now, no doubt, this single break might suffice to present an insuperable obstacle to the rapid passage of troops and munitions of war through Lahore. No doubt if, as supposed by Mr. Brunlees, an army with its baggage, commissariat, ammunition, and artillery accompaniments, was to be brought thither by the broad gauge with the view of being passed on forthwith by the narrow gauge, the confusion would be indescribable—scarcely imaginable even by those who had visited Waterloo station on the day of a Volunteer review at Wimbledon. And so similarly of Mr. Allport's hypothesis of 20,000 soldiers, or 30,000 soldiers, with horses and equipments, having to be rapidly shifted from

one set of trucks to another. If there were the smallest chance of such a contingency it would be penny wisdom indeed to suffer a break of gauge at Lahore, for the sake of almost any pecuniary saving. But his contention was that no such contingency could, by any possibility, occur. Although there would be a break of gauge at Lahore, neither troops, nor munitions of war, would ever have occasion to break gauge. Lahore being, in case of an invasion, made—as he was confirmed by Lord Lawrence in assuming it would be made—the basis of operations, and depôts and magazines of all sorts being established there, it would become the starting point for all troops and munitions proceeding westward or southward into the interior of the Punjâb; while from Lahore, westward or southward, there would everywhere be uniformity of gauge. His argument, in short, was, that all forward military movements would commence in advance of the break of gauge; so that, in regard to them, there would be no break of gauge. Now this argument was surely decisive, if it could be maintained, and against it not a syllable had been said by any one but Captain Galton; and what did he say? why, that a railway enabled an army to dispense with the formation of large magazines in its neighbourhood, for that it enabled them to draw supplies from almost unlimited distances; and Captain Galton proceeded to speak with admiration of the excellent arrangement for that purpose made by the Germans during the late war with France. But did Captain Galton really mean that the Germans had no magazines at Mayence and Coblentz, and the rest of their nearest line of fortresses, and that, whenever a gun was dismounted in the trenches before Metz or Paris, they had to wait until another could be brought up from Magdeburg or Berlin? If so, no wonder the Germans could not force their way into Metz or Paris. Greater than ever was the wonder that the Parisians, or, at any rate, the Metzians, did not break through the German lines. It would, he feared, go ill with the Government if a British general, in the field near the Bolan or the Khyber Pass, had no depôts, at least as near as Lahore, to draw upon, but, whenever guns or gunpowder failed, he had to send for them to Ishapore or Kirkee. Captain Galton further pointed out, that forward movements were not the only ones to be provided for, but that return movements likewise, and particularly those of the wounded, were to be thought of; but time pressed, and Mr. Thornton would therefore pass very lightly over what Captain Galton had said on that head. It really did not matter whether it was true or not that four wounded men and a nurse might be placed in a broad-gauge wagon, while in a narrow-

gauge wagon there would be room for only two men and a nurse. All the nursing in the world would avail little for whole trains full of sorely-wounded men, incapable—to use Captain Galton's words—of moving hand or foot, who, after being brought from Peshawur or Dadur by rail to Lahore, were not allowed to alight there, but were sent on without stopping to hospitals at an unlimited distance. Graveyards would serve as resting-places for most of the unfortunates so thoughtlessly treated, long before they reached those far-away hospitals.

There were but two points more to which it was necessary to allude. One was the capacity of the mètre-gauge vehicles to carry the field artillery that would be needed for a campaign on the frontier; the other was the numerical sufficiency, on extraordinary emergencies, of the rolling-stock of the Punjâb railway system, cut off, as it would be, from borrowing from the broad-gauge railways of the rest of India. With regard to the first, Major Williams, of the Royal Engineers, Assistant-Secretary to the Government of India, in the Railway Department, had intended to speak, and was prepared to prove the case of Government, by detailed measurements and calculations. Major Williams was, however, he was grieved to say, prevented by what had been a dangerous illness from attending the discussion; and in his absence Mr. Thornton could only suggest that, whosoever had any doubts on the subject, should accept Mr. Rendel's challenge, and, going to Lancaster, should get his doubts removed by personal inspection of the mètre-gauge carriages, which were there awaiting shipment to India. Gentlemen might also do well to recollect what had been said by Mr. Douglas Fox of the width to which narrow-gauge vehicles might safely be extended, on the Canadian narrow-gauge stock, which were identical in width with the Indian broad-gauge stock, and it would be seen how, if it were deemed desirable, stock of the same width might be adopted on the narrow gauge of the Punjâb.

With regard to the second point, Mr. Thornton repeated that, even though the Punjâb lines were of the same gauge as the generality of the existing Indian lines, the heavy engines of the latter could not travel on the light rails of the former, without soon destroying them. To this Mr. Bruce, indeed, replied that they could do so, provided only they traveled slowly enough. But Mr. Bruce forgot that the sole object in borrowing stock on military emergencies would be that of getting troops and stores moved on with extra rapidity, an object which would scarcely be answered by placing them in trains hauled by engines forbidden to travel except at a snail's pace.

The remarks in the Paper upon the needlessness of borrowing rolling-stock from other railways, even if such borrowing were possible, had been curiously twisted, by Mr. Lee Smith, into an admission on Mr. Thornton's part that the rolling-stock of the Punjâb would be insufficient, unless it were supplemented by borrowing; and Mr. Lee Smith had proceeded to fortify this interpretation of Mr. Thornton's language by independent considerations. Mr. Lee Smith throughout his speech, although exhibiting great imaginative and reasoning power, had betrayed at the same time a somewhat defective memory. He was continually fancying Mr. Thornton to have said things which it had never occurred to any one, but to Mr. Lee Smith, to say, and had then gone on to prove those things to be very ridiculous, forgetting that it was he alone who had put them into Mr. Thornton's mouth, and that therefore it was Mr. Lee Smith's nonsense, not Mr. Thornton's nonsense, that Mr. Lee Smith was refuting. He would have it, and would not be set right, that, when Mr. Thornton said that with the quantity of rolling-stock proposed for the whole Punjâb system, 12,000 men might be sent in a week from Lahore to Peshawur, he had further said that this might be done with only 2 trains a day. Mr. Lee Smith would have it that, if Mr. Thornton had not said this, he must, at any rate, have meant it; for that Mr. Lee Smith could prove that the whole rolling-stock would not suffice for more than two trains. Mr. Lee Smith's proofs were given thus:—12 trains a day, of 30 mètre-gauge vehicles each, or 360 vehicles altogether, would be required for the transport of 1,000 fully equipped men per day, or for 7,000 men per week. 11,000 men would therefore require 560 vehicles. Now, the whole length of rail from Peshawur to Kurrachee being in round numbers 1,100 miles, its aggregate rolling-stock, at the rate assumed by Mr. Thornton and understood to be proposed by Government, namely, 1 engine and 30 vehicles per 13 miles, would be 84 engines and 2,538 vehicles, which latter figure, divided by 30 vehicles—Mr. Lee Smith's allowance of vehicles for 1 train—would yield a quotient of what? According to Cocker, of about 84 trains—according to Mr. Lee Smith, of only 2 trains. What was to be thought of such arithmetic? What but that a man might be a responsible Engineer, and yet be no great adept at ciphering? Mr. Lee Smith's own sums, if he had done them rightly, must have satisfied him that the amount of rolling-stock proposed for the Punjâb would by itself amply suffice for all conceivable contingencies, and that there would never be any occasion to borrow. But, beside this, let it be recollected that, if it should by any possibility ever become desirable for the Punjâb

railways to borrow, they could not, if made on the broad gauge, borrow to any useful purpose, because the heavy stock of the adjoining broad-gauge lines could not be safely employed upon their light rails. If the almost impossible necessity of borrowing really deserved to be provided for, that might best be done by making the Punjâb lines on the narrow gauge, as was proposed, and then connecting them with the narrow-gauge lines of Rajpootana. And to this end it would by no means be necessary, as Mr. Lee Smith supposed, according to his habit of first fathering an absurd notion on his opponents, and then denouncing its absurdity, to start a junction line from Ajmere, and to carry it through a howling wilderness to Bukkur, an inventive genius less fertile than Mr. Lee Smith's might have suggested that, merely for the purpose of rendering the narrow-gauge rolling-stock of the Punjâb and Rajpootana railways interchangeable, it might be sufficient to lay a third rail on the section of broad gauge already existing between Delhi and Lahore.

Here Mr. Thornton would conclude, with many thanks for the patience with which the Meeting had listened to him, and many apologies for having trespassed so long upon their patience. What had already been said would probably be accepted as a sufficient pledge that a good deal more might—if necessary—be said in support of the points which he had endeavoured to establish, namely, that a very considerable saving would result from the adoption of the mètre gauge for the Punjâb railways, and that to counterbalance that advantage there would be next to no commercial and absolutely no strategic disadvantages. He did not flatter himself that many converts had been made to views in great part so novel. No doubt the old saw about "those who were convinced against their will" being "of the same opinion still" applied very well to each of the two parties into which the Meeting was very unequally, he feared, divided. The opinions of most of those who were present were most likely just the same as when they entered the room. Still, how much soever they might differ in other respects, they had, he trusted, at least one point of concord. He did trust that Lord Mayo would no longer be suspected of having, when adopting his narrow-gauge policy, taken up a mere idle crotchet and childish whim. He did trust that such injustice would no longer be done to the memory of so noble a member of the noble army of martyrs to public duty. In a private letter which Mr. Thornton had seen, written only two or three days before his assassination, Lord Mayo spoke of that policy as one which it would always be a pride to him to look back upon; and he

might at least be credited with not having resolved upon it without anxious deliberation, or without carefully weighing the arguments on both sides. There was yet another point on which the Meeting would probably be quite unanimous. Since the discussion had begun, before the Institution, the same question had been discussed in the House of Commons, and the Prime Minister had promised that the Government of India should be urged to reconsider the subject by the fresh lights then thrown upon it. In whatever else they might differ, they would probably all agree that it would greatly assist the Government of India in coming to, or, as he should himself prefer saying, in adhering to a right decision, if it were furnished not only with the Minutes of the House of Commons' debate, but also with those of the Discussion which was now concluding.

Mr. HAWKSLEY, President, said, he would very briefly occupy the attention of the Meeting. The discussion upon the Paper had extended over seven evenings. It had been exceedingly interesting, and he believed it had elicited opinions on both sides which were well worthy of the consideration of Engineers occupied in railway construction in all parts of the world. But with regard to this special case of India he imagined some of the most material parts of the subject had not received all that attention which they deserved; and in particular he thought that the Author had directed their attention to the subject rather too much from the economical aspect. There were other points of view which were of greater importance. India was a conquered country, and was held at that moment by force of arms. It was therefore more necessary to view the subject under the strategic aspect than it was to view it under the economical aspect. There were great nations —much greater than the United Kingdom—who, if they had not at the present moment designs upon the Eastern possessions of Great Britain, might, and probably would in a few years entertain designs upon a territory which would become even more valuable to them than it was to us. Now, it occurred to him that the whole of that part of the frontier of India which was accessible to attack should be duly protected, and that it did not signify in the least whether Great Britain spent, or whether India spent ten millions more or less in preventing the incursions of an enemy. It was clear that in a country which was eighteen times the size of the British isles, and in which there were six times the population of the British isles, and where there was a population which held—or at any time, by intrigue from without, or exasperation from within, might become induced to hold—their British rulers in disfavour, it was the duty of those rulers to protect themselves,

not only in the front but also in the rear. The Government might have an enemy invading India at the frontier, and it was quite possible that it might have a mutiny or an insurrection behind. Under those circumstances, suppose the great main lines of the country to be laid upon what he might call the break of gauge system: suppose that the army sent to the frontier should be overpowered, and suppose it should have troubles behind, and suppose it should be obliged to effect a retreat—what was to be done? When the troops came to a narrow-gauge line—a line which could not convey them, especially in the hurry of retreat, —they must get away their munitions, their stores, and their wounded, and those were to be got hastily on to that narrow-gauge line, and where were they then to come to? They were to come to a break of gauge; and then, what were they to do, with an enemy advancing rapidly upon them, and the country, on reasonable possibility, in the hands of a rebellious population? They would have no suitable carriages at hand, and they could not obtain them from a distant part of the country, and if they did come, there would be all the difficulties and delays of the transfer. Then what must happen? Why, unless there was at each change of gauge a sort of Metz or Strasburg in which the army could be received and where it could defend itself, as a matter of course the army must be lost. Now he would ask whether that was a proper state of affairs? He ventured to think, as an Englishman, it was not a proper state of affairs; and therefore he said that, irrespective of economical considerations, they ought to have all the main lines of the country made upon one gauge, and that gauge competent to all the exigencies of a possibly untoward occasion. It was, however, quite possible that in a great country like India, and especially in the naturally well protected parts, where the population was sparse, a gauge narrower than the 5 ft. 6 in. gauge might suffice for the purposes of the traffic, although it would still be subject to the inconveniences attendant upon a break of gauge at all its junctions with the main lines—and here he would observe, that the whole of India was not at the present time less densely populated than England was at the commencement of the reign of George I., and that was only a century ago, the number of acres to the people being indeed almost the same. Let them then consider whether, had railways been then known, they would not have been useful in England at that period of our history, and what would at that period have been the proper gauge? He ventured to think the mètre gauge would even then have been found wholly insufficient. What, he would ask, was to be gained by making

or substituting those narrow gauges for the main lines of India? Why, it was admitted that the main lines had not cost more—and it was a large sum—than £15,000 per mile, and it was also admitted that, under favourable circumstances, they could be now extended at something like £6,000 per mile. Suppose, then, the future main lines could be made at an average cost of £10,000 per mile, and let them also suppose, and they knew that to be about the truth, that the difference of cost between the narrow-gauge construction and the ordinary construction was about 10 per cent. The saving would be, at the most, £1,000 per mile, and if 10,000 miles were wanted, the total saving upon a broad-gauge expenditure of £100,000,000 would be only £10,000,000. But there were 200,000,000 of people, and so it would cost those 200,000,000 of natives just 1*s.* per head to find the £10,000,000, and the taxation would consequently be $\frac{1}{20}$*s.* per head per annum. He would ask them whether that was an important amount when placed in comparison with the safety of an immense empire and of the national interests, which would be involved largely in the decision the Indian Government might make with regard to the question now before the world. For his own part, whilst admitting that he thought the Indian gauge of 5 ft. 6 in. had been a mistake, and that it was an unnecessarily wide gauge, in so far as it exceeded in width the better established gauge of 4 ft. 8½ in., he should much regret to see another gauge introduced into the main-line extensions in substitution for it.

With these few observations he closed the discussion, and would now pass to another and very different subject. He was directed by the Council to address a serious word to the members of the Institution upon an irregularity which had recently crept into the discussions. A habit had been acquired of reading their speeches, instead of delivering them extemporaneously with that natural emphasis which addressed itself as well to the heart as to the ear. The Council hoped in future that the practice of reading speeches would be abandoned.

In conclusion, he had only to add he was quite sure the Meeting would feel much pleasure at having the opportunity of according to Mr. Thornton their very best thanks, as an official of the Government—though he did not submit the Paper to the Institution, or address them officially—yet as an official of the Government—for having afforded them the opportunity of discussing a most interesting and a most important subject.

[APPENDIX.

APPENDIX.

CONTENTS.

I.—" East India (Railways).—Return to an Address of the Honourable The House of Commons, dated 11 March, 1873;—for, 'Copies of Correspondence between the Government of India and Court of Directors, relating to the present Gauge of Five Feet Six Inches of the Indian Railways: And, of the Minutes of Lord Dalhousie and the Reports of the Consulting Engineers on the subject of the Gauge.'"

II.—Report of Mr. C. B. Vignoles, F.R.S., Past President Inst. C.E., on the Hindostanee Railway, September 22, 1842.

III.—Additional Memoranda as to the Swedish Railway System, by Mr. C. P. Sandberg, Assoc. Inst. C.E.

IV.—Additional Memoranda as to the Denver and Rio Grande railway, by Mr. George Allan, M. Inst. C.E.

V.—Additional Memoranda as to the Goods Traffic conveyed over the Bombay, Baroda, and Central India railway, during the years 1870 and 1871, &c., by Lieut.-Colonel J. Pitt Kennedy, M. Inst. C.E.

VI.—Report of Mr. J. E. Tanner, M. Inst. C.E., on a Light Railway to connect the larger towns of the Punjâb with Lahore, December 6, 1861.

I.—EAST INDIA RAILWAYS.—Return to an Address of the Honourable The House of Commons, dated 11 March, 1873;—for,

"COPIES of CORRESPONDENCE between the Government of India and Court of Directors, relating to the present GAUGE of Five Feet Six Inches of the INDIAN RAILWAYS:"

"And, of the MINUTES of Lord Dalhousie and the REPORTS of the Consulting Engineers on the subject of the Gauge."

India Office, 13 *March*, 1873.

W. T. THORNTON, Secretary, Public Works Department.

EXTRACT FINANCIAL LETTER from the Court of Directors of the East India Company to the Government of India, No. 27, dated 14th November, 1849.

1. AGREEABLY to the intimation conveyed to you in our letter of the 25th April last, No. 9, we now forward in the packet the deed of contract, in duplicate, between the East India Company and the East Indian Railway Company for the construction of an experimental line of railway from Calcutta towards the Upper Provinces of India. We forward likewise a copy of a deed of contract between the East India Company and the Great Indian Peninsula Railway Company for the construction of an experimental line of railway from Bombay to, or near to, Callian, with a view to its extension to the Malsej Ghaut.

2. These deeds are based upon the "terms and conditions" of which you have been already advised, and which have been accepted by the railway companies.

3. Although these deeds are so comprehensive, and appear so fully to meet the objects in view, yet, that you may the better comprehend the precise motives which have actuated both parties during the negotiations with respect to the terms of these contracts, and that you may thereby the more clearly understand their various provisions, we think that it may save much trouble in future if we now enter into a detailed explanation of each of their conditions. It is, however, highly satisfactory to know that the nobleman who is now at the head of your Government has already given much attention to railway subjects, and we anticipate that

great benefit will result in the course of your deliberations from his Lordship's experience.

* * * * * *

13. With respect to the weight of rails and the gauge of line to be employed on these railways, we are disposed to recommend those used by the North Western Company here, namely, a gauge of 4 ft. 8½ in., and a weight of rails of 84 lbs. to the yard, as combining the greatest utility and economy.

EXTRACT RAILWAY DESPATCH from the Government of India to the Court of Directors of the East India Company, dated 2nd August, 1850, No. 1.

Paragraph 5. The question regarding the breadth of gauge, and the views expressed by his Lordship[1] on that subject, will doubtless receive your Honourable Court's attentive consideration.

EXTRACT REPORT by Mr. W. Simms, C.E., Consulting Engineer to the Government of India, dated 29th April, 1850.

Paragraph 29. It is highly desirable in a country like India, where the railway system is now for the first time being introduced, and which will ultimately extend throughout the land, that one uniform standard of gauge should be adopted, and in no case to be departed from, so that whenever the various lines now and hereafter to be constructed shall meet and unite, as they assuredly will do, the facilities for transport, which is the great principle of railway practice, may experience neither check nor inconvenience.

30. The question therefore arises, what width is the most desirable to adopt as the standard of gauge. The Honourable Court of Directors in their Despatch of 14th November, 1849, paragraph 13, have expressed themselves as "disposed to recommend" (but did not order) the adoption of that known in England as the narrow gauge, namely, 4 ft. 8½ in.; but, with all due respect to the recommendation so given, I beg to state that in my judgment a wider gauge would be preferable for this country, and I would recommend the adoption of 5 ft. 6 in., or thereabouts, as I am not disposed to contend about an inch or two more or less, as I consider that immaterial.

31. After the labours of the Gauge Commissioners, and the several Parliamentary investigations on the subject of the width

---

[1] The Earl of Dalhousie.

of the gauge, the results of which are before the world, it would be waste of time to enter upon the discussion in this place.

32. The wider gauge of 5 ft. 6 in., which I would recommend for adoption (as the Court of Directors have not definitely settled the question), will give 9½ inches more space for the arrangement of the several parts of the working gear of the locomotive engines, and this additional space will be more needed in India than in Europe, not only on account of machinery itself, but it would lower the centre of gravity of both the engines and carriages, the result of which would be to lessen their lateral oscillation, and render the motion more easy and pleasant, and at the same time diminish the wear and tear.

33. The lowering of the centre of gravity consequent on the adoption of the wider gauge appears to me of great importance, for another reason, namely, the fearful storms of wind so frequent in certain seasons of the year, and I think it very probable that in one severe north-western, not to mention such hurricanes as that of 1842, the additional 9½ inches of lease might make all the difference between the safety and destruction of the trains; and one such accident, attended as it doubtless would be with great loss of life, would, probably, retard the progress of the railway system in this country very considerably.

34. The additional outlay of capital attendant upon the adoption of a 5 ft. 6 in. gauge above that of 4 ft. 8½ in. in the first instance, would be but trifling in comparison with what appear to me its more decided advantages.

35. The width of the gauge here recommended was the one I selected in my own mind soon after my arrival in India in 1845, and my subsequent experience of the country has confirmed my early views on this point. It was the width I then named (as the one I intended to recommend for adoption when the proper time arrived for so doing) to the Managing Director of the East Indian Railway Company, and by him subsequently named as the intended gauge in his communications with his company.

EXTRACT MINUTE by the Earl of Dalhousie, Governor-General of India, dated 4th July, 1850.

32. The Court of Directors have recommended, at the same time, the use of the narrow gauge of 4 ft. 8½ in. for the railway about to be constructed. Although the letter of the Court recommends, but leaves to the Government of India to determine as to the gauge which should be adopted on this occasion, I consider the

question to be one of such moment as to deserve a careful consideration and an authoritative and conclusive decision by the highest authority connected with the Indian Empire, who alone can have access to that full information and extended experience which would make such a decision really and satisfactorily conclusive.

33. The British Legislature fell unconsciously, and perhaps unavoidably, into the mischievous error of permitting the introduction of two gauges into the United Kingdom. The numerous and grievous evils which arose from that permission are well known, and will long be felt throughout all England. The Government of India has it in its power, and no doubt will carefully provide, that however widely the railway system may be extended in this Empire in the time to come, these great evils shall be averted, and that uniformity of gauge shall be rigidly enforced from the first. But I conceive that the Government should do more than this, and that now, at the very outset of railway works, it should not only determine that any uniform gauge shall be established in India, but that such uniform gauge shall be the one which science and experience may unite in selecting as the best.

34. At one time this question was much before me, and although I should not myself attempt to offer an opinion on so vexed a question, yet I may venture to form one on the recorded views of men competent in every way to judge. The evidence which was given before the Gauge Commissioners in 1846, and the evidence which has been given from time to time before the Committees of Parliament, backed as it has been by very high authority abroad, is, I venture to think, sufficient to show that the narrow gauge of 4 ft. 8½ in. (a measurement adopted originally at hap-hazard and from the accident of local circumstances) is not the best gauge for the general purposes of a railway, and that something intermediate between the narrow gauge of 4 ft. 8½ in. and the broad gauge of 7 ft. will give greater advantages than belong to the former, and will substantially command all the benefits which are secured by the latter.

35. The circumstances which have been brought forward by Mr. Simms in his report, applicable especially to this country, strengthen the reluctance which I feel to introduce the 4 ft. 8½ in. gauge into India, without a very deliberate reconsideration of the question, with reference to India, under the direction of the Honourable Court by the Board of the East Indian Railway Company. I should not have felt satisfied that I had done my duty if

I had not brought this question pointedly under the consideration of the court, requesting them formally and finally to determine whether a wider gauge than the 4 ft. 8½ in. ought not to be established in India, and whether the gauge of 6 ft., which was recommended by engineers of eminence in England, and which was preferred also, if I recollect rightly, by M. de Pambour, should not be introduced on the experimental line in Bengal, and at the same time on the line which is in course of construction at Bombay.

EXTRACT FINANCIAL DESPATCH from the Court of Directors of the East India Company to the Government of India, No. 46, dated 4th December, 1850.

Paragraph 9. With respect to the gauge, we concur in the opinion that a wider gauge than 4 ft. 8½ in. ought to be established in India, and we are disposed to think that the gauge of 5 ft. 6 in., as recommended to you by Mr. Simms, is most suitable. This decision will be communicated to the respective railway boards in this country.

EXTRACT RAILWAY DESPATCH from the Government of India to the Court of Directors of the East India Company, dated 7th March, 1851, No. 3.

3. Your Honourable Court have authorized the extent of the Indian gauge to be 5 ft. 6 in., as recommended by Mr. Simms. Major Kennedy thinks that the breadth of 6 ft., recommended by the Governor-General, would be preferable.

EXTRACT LETTER from Major J. P. Kennedy to the Secretary to the Government of India, No. 30, dated 27th February, 1851.

Paragraph 15. It is with the greatest possible satisfaction I have learned that the Honourable Court have sanctioned the enlargement of the general Indian gauge from 4 ft. 8½ in. to 5 ft. 6 in., and I trust I may be excused in proposing the still further enlargement of the gauge to six feet, as recommended by the Most Noble the Marquis of Dalhousie. If the Honourable Court will permit the reconsideration of this very important question, and allow me, in concert with any one or more professional men whom they may select, to offer them a report on the subject, I think that such a report may be submitted within a very few weeks after my arrival in England, next April. This could cause no inconvenience

or delay whatever, either as regards the works in progress in Bombay or in Bengal, and it cannot fail of being satisfactory to the Honourable Court to be furnished with such a document in reference to a most important and disputed question which has not yet received that professional investigation that it merits as regards Indian interests. It is a question that can only now be considered with profit, as, if any error be introduced, it will be beyond the reach of future remedy.

EXTRACT MINUTE by the Earl of Dalhousie, Governor-General of India, dated 11th April, 1851.

2. It does not appear, from the Despatch of the Honourable Court, whether their determination to fix the gauge at 5 ft. 6 in. was the result of any deliberate inquiry, or whether the figure was merely indicated as a mean between the extremes of the present narrow gauge, and that which I took the liberty to suggest. If the Honourable Court have fixed upon 5 ft. 6 in. for the Indian gauge on high recognised authority, and adhere to it, of course the Government has only to obey. But if this is not the case, the Court will pardon the importunity which, for their own present and future interests, urges them to take other counsel before they issue a peremptory mandate on this important point.

3. I know of old that particular figures have been fixed upon originally for a gauge, and for others proposed in substitution of it, without the author of the proposal being able to give any reason whatever for selecting the particular dimensions he had specified. The original narrow gauge of 4 ft. 8½ in. was adopted for no other reason than because it happened to be the width of the colliery tramway on which locomotive power was first tried. When a general alteration was proposed, I recollect it being said that the principle on which one gentleman proceeded was to take all the different gauges, strike the average, and propose the figure that resulted as the best universal gauge. But I think that many good reasons *were* formerly given for the superiority of a 6 ft. over the broad and narrow gauges, and I feel confident that many more could be given why that gauge should be selected for India, in preference to either of the original gauges, as to the one now suggested by the Honourable Court.

4. At all events, if formal inquiry has not been entered into, I earnestly request the Honourable Court to permit the question to be so far reconsidered as to receive such reports and evidence on

the subject as are suggested by Major Kennedy in the 15th paragraph of his present report. If this is not in accordance with the Resolution of the Honourable Court, I shall much regret it; for I think that those who come after us will see cause to lament that the originators of this great system in the East did not profit so much as they might have done by the errors of their predecessors in Europe.

EXTRACT FINANCIAL DESPATCH from the Court of Directors of the East India Company to the Government of India, No. 45, dated 20th August, 1851.

Paragraph 7. With respect to the question of gauge, to which you have again adverted, our decision in favour of the 5 ft. 6 in. gauge was arrived at, after a very careful consideration of the subject, and with the best opinions which we could obtain. That decision having been communicated to the Railway Companies, who have entered into contracts for the execution of works and for the provision of materials on the presumption that it is final, it would lead to much inconvenience and expense, if any alteration were now permitted.

II.—Report of Mr. C. B. VIGNOLES, F.R.S., Past-President Inst. C.E. (dated September 22nd, 1842).

PRELIMINARY NOTE.—The following report was drawn up between the early part of August and the latter end of September, 1842, at the request of several influential gentlemen connected with the old East India Company, who were considering the possibility of improving the communication with China across the Indian Peninsula, in connection with the steam-boat routes then recently introduced. It was received at the East India House towards the close of November, 1842,[1] and was the first document put on record relative to railways in India.

---

[1] Letter from the Secretary of the East India Company to Charles Vignoles, Esq.

SIR, *East India House, November 24th*, 1842.

Your letter of the 14th inst. enclosing a Statement and Manuscript Report on Railways in India, for presentation to the Court of Directors of the East India Company, has been duly received, and I am commanded by the Court to return you their thanks for these communications.

I am, Sir,
Your most obedient humble Servant,
(Signed) JAMES C. MELVILL,
Secretary.

It must be taken into consideration that most of the arguments in support of railways, which may now appear superfluous, were adduced more than thirty years ago, when numerous questions, since satisfactorily solved, were considered doubtful by the great body of capitalists; and that it was still in embryo whether railways for India should be undertaken at all, and if so, whether by the Imperial Government, by the then East India Company, or by private enterprise. Its Author, however, believes that the principles laid down are applicable to all times and to all countries.

C. B. V.

HINDOSTANEE RAILWAY.

1. A few years since, and, perhaps, up to the present time, the mere suggestion of establishing railway communication to any extent in India would have been considered a visionary idea; and it must be admitted that it is only those deeply interested socially, commercially, or politically in that extensive region, well studied in its hitherto unaided and undeveloped capabilities, and sensible of the rapid though silent progress of events, who can fully appreciate the importance, judge of the great results, and admit the probability of success in so vast an undertaking.

2. In proceeding to attempt a statement on such a subject, it cannot be disguised that there are numerous difficulties to be surmounted, no few prejudices to be overcome, many explanations to be made; and labouring under a sense of the weighty objections of all kinds which may be raised, *in limine*, to entertain the project at all, even in hypothetical discussion, it requires full assurance and well founded conviction existing in the mind to enable this subject to be followed up with energy, the circumstances to be discreetly considered, and the case to be distinctly and calmly discussed.

3. But when a retrospect is cast over what had to be encountered scarcely five years since, when it was proposed to establish steam

---

Letter from the Hydrographer of the East India Company to Charles Vignoles, Esq.

MY DEAR SIR, 9 *Castle Street, Holborn, October 27th*, 1842.

I return your very interesting report, and do not see anything to be improved in the Geographical part. I am much obliged to you for the perusal of it.

Yours very truly,

(Signed) J. WALKER.

communication with India through the Red Sea by a regular monthly post, and knowing and appreciating the advantages from its creation and continuance, it is felt that this collateral question of a railway will soon reduce itself to definable limits of expense, direction, and returns.

4. It is but nine or ten years since that the idea of uniting London and Paris by railway communication was started, yet, with the capital and enterprise of the United Kingdom, the connection is already made in two directions on the English side of the Channel, and in one course through France; and would long since have extended by other lines over that country had the jealousy, distrust, and procrastination of the French government permitted.

5. Within the same period has the face of Great Britain been tattooed, as it were, with railway lines, to the extent of 2,000 miles, at a reckless and excessive cost, it is true, but still to the great advantage of the country. Belgium has spread a network of iron tracks over her fertile plains, and the formation of railways is discussed in every part of Europe with a sincerity and perseverance that presage their speedy realisation in many directions; and in spite of the pecuniary losses, which, it is hoped, will but serve in future as beacons, the positive and lucrative returns from no few of the existing lines have sufficiently broken through the circles of doubt, misapprehension, and mistrust which environ all great innovations, and capitalists now seek only for localities most favourable for the development of the resources of a country whereon to direct their speculations.

6. It may therefore be assumed that a railway through Hindostan will be characterised as an enterprise of that aspiring character, and worthy of the present age, if reasonable probabilities of ultimate successful results can be demonstrated; and, admitting that such will be proven, surely the present perfect realisation of the railway system itself, the accumulating wealth of the British empire, the settlement of the most vexatious political questions, giving assurance of the repose of Europe, indeed, of the world, all favourably unite in conducing to a satisfactory view of such a project; and, unstartled by its novelty and boldness, undismayed by its gigantic nature, the spirit of our enterprising and intelligent merchant princes will look to it not as a question of execution or non-execution, but simply to determine who are the proper and influential parties to bring such a mighty measure before the public—a measure which will be shown to present most extraordinary claims to attention, and while changing the features of the

country, practically, at least, is calculated to produce results almost startling to contemplate.

7. The nearest parallel cases to such a project as herein suggested are to be found in the numerous lines of railway already executed, and the still greater number proposed, and partly commenced, through different localities in the United States of America. The capital of our country has been thoughtlessly lent to these transatlantic rivals, and has made them improved communications for bringing down to their seaports those staple commodities which India can produce in still greater abundance and in greater perfection, if the proper means are applied; and as experience has since pointed out the true causes of former failures, it may be assumed the certainty of future success in this respect is ensured. The needy planters of America, having had canals and railroads made through their swamps and pine-barrens, laugh at the credulous English capitalist, and repudiate the securities given for the money which has created what they wanted; and he is not only refused either principal or interest, but sees the means assured to his dishonest rivals of bringing their productions with economy and regularity to the seaport, to be purchased by the English consumer; thus prejudicing our Indian possessions, with soils lying fallow and capabilities dormant, which, cultivated and aroused, would supersede the American, and open new and untaxed markets to those British manufactures, of which the jealousy of America is impeding the consumption, in her own states, by prohibitory duties, in foolish imitation of European countries.

8. It is, therefore, not unreasonable to suppose that the revival of our finances, and the pacific settlement of all our political relations, will be soon accumulating capital, which cannot long remain unemployed, and that the possessors will be seeking new channels for investment; nor can it be considered visionary to assume if long lines of railway in the states of Virginia, Carolina, Alabama, Lousiana, &c., to convey cotton and tobacco to the seaports can be cheaply and profitably made, that it will be equally politic, important, and beneficial to bring, by the same means, the cotton, rice, tobacco, sugar, indigo, oil, and all the many other rich products of India, to rival the production of America in our home markets.

9. If Cuba requires, and has made, railways from the interior of that island to the coast to supersede the mule and the bullock, is it not equally desirable that the example should be followed in India?

10. If it be worthy the attention of the Russian monarch to

promote railways, as he is doing, from Cracow to Warsaw, and thence to the Baltic shipping ports; and from Moscow to Petersburg, down to the mouth of the Neva, through territories sparsely inhabited, but still yielding natural articles of commerce, it cannot be matter of surprise, if those who have maturely considered the resources of British India, should deem it equally facile, equally desirable, and probably more advantageous, thus to pervade the fertile regions of Hindostan.

11. On entering into the inquiry relative to railways in Hindostan, it may be convenient to consider the subject under distinct heads, namely:—

1. Are railways through India practicable?
2. Can they be first constructed, and afterwards worked at a moderate expense?
3. In what direction should they be taken to ensure, in the most extended sense, the greatest beneficial results?

12. The first of these inquiries may be answered without difficulty. Through the thickest of the American and Cuban woods, across some of their wildest torrents, and in districts where apparently insurmountable physical obstacles existed, railways have been carried. Through every part of India native engineering talent, unaided by any European skill or science, has often overcome vast difficulties with economy and success: their architectural taste, resources, and military constructions prove their capability of executing still more difficult operations, when the experience, energy, and art of this country comes to direct them. The facility with which some most extraordinary hydraulic constructions have been completed in India by the natives, render the corresponding works for railways comparatively simple.

13. Many of the bridges, embankments, tanks, pagodas, mausoleums, and other useful and ornamental works of India, are of a far greater and more expensive character than the railways under consideration. Timber and stone are in abundance in one or other of the districts; and where the native skill, labour, or natural resources cannot furnish iron—which is, however, to be anticipated it may do in some parts with advantage—the supply from the mother country will be very little more costly to India than to America.

14. As regards the features of the country, it is evident without going into detail, and without reference to particular localities, will be but occasionally, and at long intervals, that peculiar

points of difficulty may be anticipated—India, geologically and physically considered, consists of vast plains and table-lands, divided by ranges of mountains, with many passes and defiles, or ghauts—so termed in the language of the country—which, occasionally steep, are seldom so long or so difficult, and probably will be found much less so, when examined by the eye of an experienced engineer. With very few exceptions, the numerous rivers and water-courses intersecting the plains are only formidable in the rainy season, and during the rest of the year afford opportunity, and sure means for bridging, with facility and at moderate expense. The modern resources of engineering have taught us that the difficulties of railway gradients may be overcome in various ways, which it is not necessary at present to discuss; and daily practice in working railways in Europe and America proves, that even on lines of very great traffic, a maximum load for the moving power employed is so seldom attached to any one train, that a railway in its longitudinal section may be undulated to a much greater extent, and with far less inconvenience, from a truly horizontal, or level line, than was supposed in the outset of the creation of these means of transit.

15. In short, the practical experience and actual working of railways, both in England and America, over as steep rates of ascent, as are likely to be met with in India, show sufficiently to the engineer that the features of that country present no invincible obstacles; while the resources of labour and materials offer facilities superior to either of the other countries. Without therefore entering into the consideration of the actual means, it may be safely and conclusively stated, that whether to pass the great rivers, or to surmount the steep ghauts of India, modern engineering offers many cheap and easy appliances.

16. This naturally leads to the second question, as to the cost of construction; and here it will be at once fully conceded, that if this cost should be likely to amount to what has been the average of railway expenditure in the United Kingdom there must be a final stop to the matter. But an assumption of the probable cost of such works in India being equal to the positive cost in Great Britain or even in other parts of Europe would be most deceptive. Highly improved countries such as those, are full of artificial works and are already abounding in various improvements and existing communications which have preoccupied the ground; these, when disturbed by new constructions, must be restored; and this it is which has added vastly to railway expenditure; with such great value attached to the property necessary to be obtained, many

unforeseen expenses have to be incurred in Europe when a fresh opening of any kind, whether road, canal, or railway, has to be made.

17. The parallel of expense for India has therefore to be sought in other and less improved countries than ours. The railway system has been long enough at work to afford sufficient insight into this inquiry in a general way. The average of the many railways in England shows a gross expenditure of upwards of £30,000 sterling per English mile, while that of the Belgian railways is scarcely half that sum, namely, about £16,000 or £17,000 per mile. The average of the railways throughout Germany is £10,000 per mile, and the railways of Russia and Poland will be no more than £7,000 to £8,000, which latter sum is about the average of those in the United States of America.

18. In that country the longest and most recently finished line is the one from Boston to Albany, through the States of Massachusetts, Connecticut, and New York, a distance of nearly 200 miles across a peculiarly difficult country (more so, on the average, than most parts of India), and where labour and iron are particularly dear. This line, which is called the "Western Railway," 197½ miles long, has been completed in every respect for the sum of £1,729,645 sterling, including stations, carrying, establishment, &c., being £8,758 per mile. As more than two-fifths of this sum was for earthwork only, in which the Hindoos have much experience, it may be safely assumed that a considerable diminution from this part of the expense would be attainable, with proper management, on a Hindostanee railway.

19. Although it may be thought somewhat too much in detail, it is advisable here to give the principal heads of this expenditure in order to prove the correctness of the assumption. The above sum of £8,758 was thus divided :—

	£	
Land and fencing, about	500	per mile.
Earth and rock excavation	3,800	„
Bridging, masonry, and works of art	1,000	„
Railway proper, or upper works (of which two-thirds for iron)	1,800	„
Stations, &c.	300	„
Engines, carriages, and carrying establishment	700	„
Sundries	158	„
Management about 6 per cent.	500	„
Total	£8,758	„

20. Now it appears from the preceding abstract, that the great item of cost in this American railway was the leveling of the

ground, labour being high and the country rough with many streams. With the experience of all that has been previously done, and with all the resources of the country, it is clear, in the absence of the detailed and specific information, which can only be collected when this matter is much more advanced, that the sum of £8,000 per mile may be taken as the cost of first construction of railways throughout India, without reference at present to particular localities. It may be presumed that the items of land and fencing in Indian lines would be comparatively nothing; the cost of a bridged and metalled road in any of the presidencies has seldom exceeded £300 per mile hitherto. Therefore, supposing all the other sums to be as on the American railways, there would be a very large margin per mile to meet the extra expenses of formation and bridging which a railway might require.

21. In respect of cost of working there are perhaps better materials to guide the inquiry. The average of the cost of several years' working in the Belgian railways is about 4*s.* per mile per train. On the German railways it is about 3*s.* 6*d.* On the Dublin and Kingstown railway it has hitherto seldom exceeded 3*s.* 4*d.* On the North Union railway it was only 3*s.* for the last year, exclusive of the government duty and parochial taxes, of which there would be probably none in India; and the average of the working for the last two or three years on a number of railways in the United States gives us 3*s.* per train per mile; some being as low as 2*s.* 9*d.* where wood is the chief fuel. Here again, without the necessity of going into details, it is to be fairly assumed that, with the low price of Indian labour, 3*s.* per train per mile may be taken as sufficient to cover (as it does on the lines quoted) all the various expenses, which it may not be uninteresting here to abstract, namely:—

	s.	*d.*
Locomotive power	1	3
Carriages	0	3
Maintaining of railway	0	6
Police	0	2
Conducting traffic	0	5
Miscellaneous expenses	0	2
Management	0	3
Total railway expenses per train per mile	3	0

22. Now on the lines of very lowest traffic in the United Kingdom the gross receipts are 40*s.* per mile per day. And supposing the revenue on Hindostanee railways not to exceed this

sum, and that to gain it, it were needful on the average to travel over each mile six times daily, there would be a net profit per mile of 21*s.* per day or £400 a-year, which would yield five per cent. on a first expenditure of £8,000, and four per cent. on that of £10,000 per mile.

23. The cost of palanquin dak traveling in India is about 2*s.* per mile for a single person carried, and the rate for transport by camels, bullocks, or carts, is from 6*d.* to 1*s.* per ton per mile, even where a full load can be borne. Taking the railway charge at an average of 1½*d.* per passenger per mile, and 2*d.* per ton per mile for goods, which are extremely low rates, it will be seen that a very moderate traffic indeed would soon produce the above gross revenue of 40*s.* per mile per day. Indeed, on the part of the railways nearest to the seaports and to large towns, it would be so very much greater that a considerable surplus must be available to make up the deficiency on the remote and unprofitable parts of the system; and it is the very principle of a great system of railways to lead to such a result.

24. Another mode of calculating railway expenses, as deduced from the same and similar data, shows that the cost of working, including all deductions from the gross receipt, may be taken thus, namely:—

	Per Mile.
Passengers	½*d.* each.
Coal and mineral traffic	¼*d.* per ton.
Merchandize	1*d.* "

and it will then remain to be considered what should be the smallest augmentation above these cost prices to make, as the railway charges, so as by low rates to induce the greatest traffic, and consequently the best returns.

25. It is presumed that a sufficient *primâ facie* case has now been made out to allow the second question to be assumed as disposed of for the present.

26. Hitherto the subject has been dealt with purely and abstractedly as a commercial speculation; but in proceeding to enter on the third and most important question of the directions in which the railways should be carried, objects of a higher class enter into the consideration and require to be maturely discussed. Still it may not be inadvisable at first to assume a specific course which shall define termini and form an integral line; such a one it is to which attention has been called, and which has, indeed, given rise to this inquiry, and into the particular merits of which an investigation must therefore be made.

27. From the great scale on which the districts of Hindostan have been formed by Nature, the distances become vast in comparison with those in Europe, and it is only on the American railways that any analogy of extension can be found; thus the railway that has been suggested from Bombay, on the western side of the Indian peninsula, to Masulipatam, in the Bay of Bengal, would extend little short of 700 miles. In the absence of minute surveys, and especially of levels, it is not possible to define with certainty the exact course of this or of any other line in Hindoostan. Still, from the maps, books, and documents to which access has been so freely granted through the liberality of the East India Company, and the urbanity of their officers, an approximate idea may be formed of the course of the line which has been suggested.

28. On many accounts, for which on a future occasion valid reasons may be assigned, it seems advisable to proceed from Bombay, through the island of Salsette, and to form a connection with the continent at some convenient point below Tanna, by means of a floating bridge, such as in use at Plymouth, Portsmouth, &c., but capable of taking a railway train; thence to proceed across the Concan, and by the most practicable of the Ghauts to the table-land above.

29. The difficulties here may be surmounted easily and economically by means of the atmospheric principle of producing locomotion, as now in course of construction for the extension of the Dublin and Kingstown railway to Dalkey Common on the Killiney Hills; on this principle it has also been proposed by more than one railway Engineer to surmount difficult points such as the defiles of the Apennines between Genoa and Turin, the rugged country between the Rhine and the Danube, the Splugen pass across the Alps towards Lake Como, the passage of the Tyrol between the valleys of the Inn and of the Adige, and in other places in Europe.

30. From the table-land above the Ghauts a practicable line for a railway may be formed to the vicinity of the station and city of Poona; thence the country is quite open, and the general and gradual descent by the great water-courses may be followed, passing near Soolapoor and thence to some point between Kilburga and Ferozabad, when it will be necessary to quit the valley of the Bheema river, and follows up the course of one of its tributaries called the Kurgan, by the town of Moolkeir, to the head of the valley at Purgee, which would be a culminating point or summit on a ridge which it seems impossible to avoid, though no serious obstacle is likely to occur. From the Purgee summit the direction will be along the course of one of the head branches of the Moosy

river to the city of Hyderabad, the capital of the dominions of the Nizam.

31. Although this part of the country is little known to Europeans by published description, the detailed part of the great trigonometrical survey of India has been completed throughout from hence to the Bay of Bengal; and guided by these valuable and important maps, though of course not yet corroborated by levels, it is considered that a practicable route will be easily obtained by the valley of the Moosy for fifty or sixty miles, when this valley will probably be found to expand sufficiently to allow the course of the railway to be turned in a south-east direction, and, perhaps, nearly straight to the left bank of the Krishna river at the great bend where the Pallais river falls into the larger stream, near a town called Moogatabad; thence, in the same direction, across the Moonyair river at the lower forks, and on by the diamond mines of Purtgall to the pass of Condapilly, and along the banks of the Krishna to the town of Bezawada—whence the passage towards Madras is generally made—and then in a direct line across the flats to Masulipatam.

32. The following would be the probable itinerary, namely:—

	Miles.
Bombay, through the Island of Salsette	32
From thence to the vicinity of Poona	90
From Poona to the south of Soolapoor	157
From near Soolapoor to about Ferozabad	85
Ferozabad to the Purgee summit	65
Purgee summit to Hyderabad	42
Hyderabad to Moogatabad	121
Moogatabad to Bezawada	43
Bezawada to Masulipatam	44
Total miles	679

And it must be observed that as the detailed character of the line cannot be known, and may require deviations and detours to be made for the purpose of avoiding difficulties and facilitating gradients, it is expedient to call this about 700 miles, or, say, an expenditure of six millions sterling, which, from the generally easy nature of the principal part of the distance, and the facilities of obtaining labour and all materials except the rails, may be taken as a safe approximate estimate.

33. It has to be inquired what pecuniary return, and what general and political advantages may be anticipated from a line of railway in the above direction, not omitting to consider the probable future development of resources, and opening of additional

facilities of communication to points beyond the terminus, as well as the general bearing on the means and resources of the other parts of India not directly pervaded or served by the contemplated line.

34. In a commercial point of view there is no question that the greatest advantages would be obtained for the trade of Bombay by opening up such a communication with the interior as the proposed railway. At present the western part of India may be said to be almost without roads at all, and none that can sustain any heavy commercial or military traffic. Into Bombay itself there are at this time only two lines leading; indeed, for the nearest twenty-five miles, but one road. Throughout four of the collectorates adjacent to Bombay, namely, Poona, Ahmednuggur, and the two Concans, an area of considerably upwards of 30,000 square miles, and fully equal in superficies to the whole of Ireland, there were, within the last three years, little more than 400 miles of roads, of which only one-half were passable at all; and at present there are scarcely 600 miles, whereof eighty or ninety only are practicable for carriages in the rainy seasons, which last for fully one-third of the whole year.

35. All the towns and posts of the interior are, therefore, so many isolated points during the rains; and however important it might be either in a military or commercial sense, it is impossible to pass heavy carriages along the roads, which have been constructed without any care or cost as to their foundations, and have no bridges at all, with very rare exceptions, and but few ferry boats.

36. Over many of the roads, especially through the Ghauts, wheeled carriages cannot pass at all, and yet the slight improvements which have taken place of late years demonstrate the truth of the remark—prevailing in India as in all other parts of the world—of the vast increase of intercourse where facilities of communication are afforded. Thus, by a slight improvement in the road leading to Nassuck, the number of carts coming with grain into the town had quadrupled in two years. On another road through the Concan, and within forty miles of Bombay, where formerly there were no carts used for traffic at all, there are now great numbers, and every wheelwright in the different villages has full occupation in constructing new ones. On the only good road, namely, between Panwell and Poona, the number of carts passing the Bhore Ghaut had quadrupled within four years—the number being now nearly 700 daily.

37. On the other hand, there is a very great cart traffic through

another district of the upper country, but the carriage road stops at the top of the Tholl Ghaut, about 70 miles from Bombay. Here nineteen-twentieths of the goods are shifted on to bullocks and thus conveyed for the rest of the journey, the carts returning empty over 200 or 300 miles of country, although, were there a good road to the shipping place these same carts might take into the interior a return lading of salt, hardware, &c. &c. which has now to be transported by bullocks, thus limiting and diminishing the consumption by this needless expense of carriage.

38. These instances might be greatly multiplied if necessary. The consequences may be readily inferred. Traffic and commerce are not only greatly impeded, cramped and broken up by false expenses, but the existing trade is turned in another direction. For instance, the chief products of the Oomrawattee districts, all westward of Baulapoor, already find their way to Bengal by way of Mirzapoor and the Ganges: although, by going to Calcutta instead of Bombay, the merchants have from 100 to 200 additional miles of land carriage, besides all the water transport, down the river of many hundred miles.

39. It would, therefore, seem incontrovertible to insist that a main trunk line of railway pervading the wide fertile districts eastward of Bombay would present all the advantages of a navigable river open at every season of the year; and, if made, would be joined by various branch roads suited to the traffic from the several towns and districts to a great extent on either side; the best description of firmly-made and well-bridged road, costing from £200 to £300 per mile, and the minor routes for fair-weather traffic averaging only about £50 per mile.

40. In carrying a line of railway across the peninsula of India the leading feature, as in that of any other great railway system, must be to connect the extreme points on each coast, and to leave the districts pervaded by the main trunk to provide communications, by public or private means, to the nearest or most eligible points. The institution of a principal and leading line will derive its prosperity and success by the number of ramifications from its trunk, at the same time imparting great facilities to the country: the benefit being mutual—the support interchanged.

41. The same arguments apply to the mercantile connection between the interior of the eastern side of the peninsula and the port of Masulipatam; and there will be, of course, a point in the dominion of the Nizam, probably somewhat east of Hyderabad, where the current of traffic will divide, flowing westward to Bombay and eastward to the Bay of Bengal. The whole of the

immense territory between Soolapoor and Masulipatam may be said to be totally destitute of any but the very rudest means of transport; and the transit of a railway will present to the districts on each side a double line of coast, as it were, on which each station would be a port, and would become a depôt for the collection of the products of the country and for the distribution of the manufactures of Great Britain, at prices so greatly reduced by the saving of the present cost of carriage as to place them within reach of a class of persons now wholly unable to obtain them, and at the same time for these same individuals present a local mart established for the fruits of their own industry.

42. Judging from the latest reports of the Bombay Chamber of Commerce and by the returns from the various collectorates, there appears no reason to doubt, even under all the existing difficulties of bad culture, tardy improvement, unskilful preparation of the produce for market, and the limited means of lateral conveyance, there would be a traffic sufficient to form a fair revenue for a railway.

43. For instance, the "Barsee cotton" of the Bombay market is collected at the town of that name from two or three small districts only of the Nizam's dominions; and the annual quantity sent from them was, four years since (the latest accounts), upwards of 40,000 bales, all which must have been carried full 300 miles on bullocks or in bullock carts from the places of growth.

44. The statements of Dr. Gibson, Professor Royle, and other competent authorities up to the most recent periods show that there is no limit to the production of cotton, sugar, silk, tobacco, and numerous valuable staple articles of produce and commerce as far as soil and climate are concerned. A more careful attention and greater skill bestowed, will always command the Bombay market for this produce; and the introduction of European capital, enterprise, energy, and system will gradually, and no doubt rapidly, produce this effect if proper arrangements and suitable opportunity be afforded.

45. In regard to passenger traffic, this must be the natural consequence of economy and expedition in the means of conveyance. In Belgium, Ireland, Scotland, Germany, &c., where low rates exist, the movement among the very lowest class has been most extraordinary, and the increase seldom less than fourfold.

46. But to complete the statistical information and detailed returns necessary to be obtained and investigated, to solve accurately the question of traffic, would require much greater time than it has been possible to devote to the subject, even if the mate-

rials existed at all, or at any rate if existing in this country. The same, indeed, with respect to the estimates of construction; but there remains the very highest probability that the more these inquiries are gone into in detail, the more likely are they to result in proving that the requisite capital would be comparatively small, and the probable returns from merchandise and produce only, very great.

47. To take, however, a more extended view of the subject, the railway communication from Bombay to Masulipatam should be considered as part of the probable future route to China, whereby, in connection with the contemplated passage across the Isthmus of Siam from Mergui, on the Tenasserim coast, to the Gulf of Siam, the distance between the Straits of Bab-el Mendib and the China Sea would be reduced to 1,000 miles less than by the present route, *viâ* Bombay and Ceylon; and, what is a greater advantage, there would be a diminution of 1,800 miles of the sea voyage. Even in comparison with the route direct from the Red Sea to Ceylon, the advantages would be extremely great; for though the positive gain in distance would not be more than about 200 miles, there would be 1,000 miles less of sea.

48. This will be shown at once by the following abstract of the distances on the respective routes :—

Present Sea Route by Bombay, Ceylon, and Singapore.		Direct Sea Route to Ceylon and Singapore.		Overland Land Routes across the Peninsula of Hindostan and Siam.	
	Miles.		Miles.		Miles.
Socatra to Bombay	1,400	Socatra to Ceylon .	1,900	Socatra to Bombay	1,400
Bombay to Ceylon	1,300	Ceylon to Singapore	1,700	Overland to Masulipatam .	700
Ceylon to Singapore	1,700	Singapore to Macao	1,600	Masulipatam to Mergui . .	1,200
Singapore to Macao	1,600	All sea.—Miles .	5,200	Across Siamese country . .	100
All sea.—Miles	6,000			Siam to Macao .	1,600
					5,000
Total additional distance . .	1,000	Total additional distance . .	200	Deduct land journey . .	800
Total additional sea voyage .	1,800	Total additional sea voyage . .	1,000	Sea voyage.—Miles	4,200

49. As regards the general advantage to Madras and Calcutta, the line across from Bombay to Masulipatam will place both these ports in a better situation to communicate with the mother country; for, either by land or water, Madras may be reached in two days

from Masulipatam, which latter by railway would be only from 24 to 30 hours' journey from Bombay, being a gain of five days over the present mail time, and still more over the Bangy post. The gain in time to Calcutta by land mail would also be about five or six days, computing a week's journey from Masulipatam. It is probable, however, that regular steamboats would ply from the latter port both to Madras and to Calcutta.

50. In a military point of view, also, the contemplated railway must be highly advantageous; and affording such increased facilities and diminished time and expense of communication to Madras, Calcutta, China, and all the Eastern Archipelago, it is no more than right to assume a great traffic, doubtless yet to be created, but which cannot fail to arise.

51. To give due effect to the acceleration of the traveler, the merchant, the soldier, and the statesman, arrangements should be simultaneously made to put on regular lines of steam-packets; nor should the probability of forming another railway across the Isthmus of Suez sooner or later be lost sight of; and it may be interesting to state that serious negotiations are now going on with several of the European Governments, the effect of which, if brought to a satisfactory conclusion—of which there is little doubt—will be to obtain a railway communication from the English Channel to the Mediterranean at some eligible port in Italy, independent of France, ensuring some further reduction of time and a certain uninterrupted transit. All these public advantages are sufficiently evident without it being necessary to enlarge upon them, and bearing as they do on the question of the Hindostanee railway, become powerful arguments for its support.

52. It must, however, be distinctly stated that most of the general arguments in favour of railways in India, not even excluding the combination which improved communication between Europe and China, as will be shown, are almost as equally applicable to any line extending from Bombay eastward, as to the supposed railway from Bombay to Masulipatam, which, in strictness, ought to be investigated purely on its local merits; when, after deciding favourably on the great principle of having railways at all, the next point to be mooted is the precise direction. Considered in this light, several doubts may be reasonably started against the above line: such as the eligibility of Masulipatam as a steam-packet station during all periods of the two monsoons, and the fact of so large an extent of territory to be pervaded—fully one-half of the entire distance between the two coasts—not appertaining directly to the British territories. The former might be left to

the decision of competent naval authorities, but it is difficult in regard to the latter.

53. The ultimate success of so vast an undertaking as an Indian railway system must necessarily be based on the future improvement of the country and the fuller development of its resources; to effect these indispensable results will require every encouragement, facility, advantage, and support from the ruling powers, and every freedom from the contingency of transit-duties and local and uncertain impediments: or, granting all apprehensions on this subject to be removed, still, the unwise rule of the native governments—so long exercising a prejudicial, and too often baneful and fatal, influence on their subjects—grinding them down by excessive taxation and restrictive measures—gives but too much reason to apprehend that profitable returns might not be so soon reaped from districts such as those not exclusively under British control; and Confidence, that spoiled child of Peace and Freedom, reared by Experience, might long hold back her aid in enabling the beneficial results of such a mighty speculation to be speedily realised.

54. Further, it has been supposed that some serious objections on the score of climate might be brought forward respecting the location of the railway through the northern Circar between the Krishna and the Godavery rivers. It is also clear, from the geological features of the whole of this particular line, that there is not any coal; and latterly it has been demonstrated that there is no hope of any of the minerals which former accounts had held out as abundantly existing in the eastern districts of the Indian peninsula—the magnetic iron ore perhaps excepted—nothing in addition to the rich vegetable productions of the country, save, possibly, what might be hoped from a better mode of working those almost abandoned diamond mines which, under the name of 'Golconda,' have been so famous for ages, and whereof the same authorities who so dispassionately broke down all expectation of copper, lead, and similar metallic veins, seem to consider might yet, under European management, prove sources of wealth to enterprising adventurers.

55. Not that it is doubted that from the natural productions of the soil only, advantageous returns may be derived; but if localities are to be found combining mineral as well as vegetable wealth, such localities are naturally preferable; considering, also, that for any great military purpose of defence or intercommunication in the various parts of Hindostan, a line from Bombay to Masulipatam may not be found the best, it becomes desirable to seek for, or at least to discuss the eligibility of, other routes which may not only serve the purposes of commerce and internal com-

munication to a still greater extent, but, by combining many other important public and natural advantages and desiderata, enlist not only the sympathies of all classes of the community, through the greatest area of wealth, population, and industry, but the cordial support and co-operation of the Government of India and that of the United Kingdom.

56. In short, to follow out to its uttermost the grand principle enunciated and adopted by the East India Company and by Parliament when the great question of steam navigation to Asia was discussed in 1834, namely, "If this measure were undertaken "it ought to be executed on a large and efficient scale, and that "between doing it thus effectively and comprehensively and not "doing it at all there is no advisable medium." In such a principle all the merchants of the East most cordially concurred, and there cannot exist a doubt that a similar and simultaneous accord and combined effort can alone bring to maturity this corresponding enterprise which it has been attempted here to investigate and recommend. In fact, to do less would be inexpedient even on the score of economy; for, viewing the expense as a great whole, the cost of establishing and maintaining such a work as a railway would be but inconsiderably increased by giving it a further practicable extension beyond the minor measure first suggested, and the benefits, from being comparatively partial, would be extended in a vastly augmented proportion to the original expenditure; for in carrying out a magnificent project such as this, in which the account total is by millions, it becomes a wise and politic step to render it as comprehensive as possible.

57. With these principles therefore as a guide to enter into the discussion of some other direction for the exercise of a bold but deliberate and matured spirit of speculation, or rather demonstration of national foresight, let it be at once supposed that a line be sought and traced for a railway from Bombay to Calcutta and its particular merits investigated. Measured along the arc of a great circle the absolute distance between Bombay and Calcutta is little more than 1,000 miles, the great military post of Nagpoor being nearly on the line.

58. There are, however, physical difficulties herein of no ordinary kind, and those acquainted with the topographical features of the country know, that for at least one-third of the distance such a course would be over wild hills, amid a savage population, and through a desolate and almost uncultivated country; but partly subjugated by the Mahommedan invaders of India, and even at the present time but little known. There is also the former

difficulty of half of the route only being within British dominion, and other causes of objection similar to those which might be urged against the line to Masulipatam.

59. It is well known to geographers that at the southern base of the Great Vindhyan range of mountains, running from west to east, there flows the Nerbudda river, the head waters whereof rise within a mile or two of the sources of a principal branch of the Sone river, which is one of the great tributaries of the Ganges, and thus what may be called a natural engineering line exists between the Gulf of Cambay and the Bay of Bengal; and if a course be taken from Bombay towards Calcutta so as to fall into the valley of the Nerbudda river, and if that stream and the Sone be followed as far as necessary on to the great plains of Bengal, an easy and not very indirect course to Calcutta would be obtained, having the advantage of passing through or near most of the great coal and iron districts which have lately been discovered; pervading at the same time an extremely fertile district, nearly the entire of which is British territory; a very large portion highly cultivated and thickly peopled, and but few parts of a wild, and none of a sterile, character; and everywhere capable of the very highest degree of improvement, and of furnishing all the necessaries of life, and the most valuable productions, for which Europe offers an unfailing market; and in addition to all the local advantages and commercial benefits to the country itself, and to the great empires at each extremity, such a line forms remarkable means for facilitating several great national objects.

60. In attempting to describe the route such a railway would probably take, it is done with similar reservations and remarks to those applied to the line first considered. Starting from Bombay, the island of Salsette would be traversed to Tanna, and the main land be attained in the way before mentioned by a steam floating bridge; passing thence, probably, to the north of Callianee, the line would be directed by the most eligible ghaut in the Syadree range to rise into the upper country above some of the head waters of the Godavery river, then proceed in the vicinity of Nassuck and Guntoor, filing by one of the ghauts of the Injyadree range into Candeish.

61. The course would take this fertile province in its longest length, and be directed upon the large and important city of Bhoorampoor, in the rich and flourishing valley of the Taptee river, and near the celebrated fort of Adjyeghur on the south side of the Sautpoora range. To this point the British territories extend without interruption. A passage through the ridge may

be found with little difficulty, and thus take the railway into the valley of the Nerbudda river, attaining the banks of that great stream somewhat to the east of Hindia, when the line would again enter our dominions, having passed for about 90 or 100 miles through the south-east corner of Malwa, over a district belonging to the independent state of Sindia.

62. From thence the course will be along the valley of the Nerbudda, by Hoshungabad—where coal and iron are found—to the meeting of the waters at Sacur, still in the coal-field, and near the wealthy town of Jubbulpoor, the capital of these districts, situated on the main stream of the Nerbudda, about 30 miles east of Sacur; from this latter place the northern branch of the river would be followed to the culminating point or summit, and then over the ghaut to Belhari, a town situated at the very head of a great branch of the Sone river; this branch would be pursued down to its junction with the main arm of that stream, and the line go still down the valley, probably on the northern side, until past Burdee, to the mouth of the Coyle river, passing by the great coal-fields, and probably about 50 miles from Allahabad, Mirzapoor, Benares, and Ghazipoor. From a little east of Belhari for a distance of 40 miles the line would intersect the south-east angle of Bundelcund—which here extends across the north branch of the Sone river—afterwards keep for about 100 miles in the territories of Rewah Rajah, re-entering the British possessions near Burdee, not again to leave them.

63. Emerging on to the great plains of the Ganges the course would then be brought not more than 50 miles from Patna, and near Gaya and Berar, both large and populous towns, the former known as a place of extraordinary great annual religious resort; then, following a lateral valley eastward and over a small ridge of hills, the line would descend to the streams which form the sources of the Hadji and Damoora rivers, pursue the general direction of their valleys by the coal-fields lying between them and to the vicinity of Burdwan, and from that town proceed direct to the right bank of the Hooghly river, opposite Calcutta.

64. It should be observed that there is no river along the whole of this long range of country likely to present any serious difficulty whatever, or to require any peculiar construction, and it may be repeated that the successive passage of the first three principal ranges of mountains and of the other two summits may be satisfactorily effected by means of the atmospheric system before alluded to.

65. Should, however, circumstances, which will be presently

discussed, make it desirable or necessary to push the line of railway well towards the north-west frontier of India before turning eastward towards Bengal, then what may be styled an alternative course may be found in the following direction, namely:—

66. Leaving Bombay and attaining the main land from the island of Salsette, as previously described, keep the railway nearly due north and parallel to the coast, cross the Taptee river near Surat and gain the banks of the Nerbudda in the vicinity of Baroche—sometimes called Broach—then follow that river upwards to Hindia and Hoshungabad, joining on to the route previously described.

67. Such a course would, however, add fully one hundred miles to the distance, probably encounter serious and as yet unknown difficulties along that part of the Nerbudda where it forces a passage through the approaching mountains, and traverse for 250 miles wild territory in Ghuzarat and Malwa, not belonging to Great Britain, chiefly under the dominion of Holcar, but including parts subject to Kotah and to Sindia. Such a detour under such circumstances would however certainly be admissible from a high grade of political and commercial considerations, the value whereof must be judged of by those well versed in this subject, and capable of taking the most enlarged views.

67. The following would be the itinerary of the lines from Bombay to Calcutta by Nassuck, Bhooranpoor, &c., as first described:—

	Miles.
Bombay through the island of Salsette	25
From thence to the vicinity of Nassuck	75
Nassuck to the Injyadree range, near Chandore	40
Through Candeish to Buooranpoor	150
To the Gynial river, in the Nerbudda valley, east of Hindia (coal-fields)	100
To the Towah river, near Hoshungabad	40
To the forks of the Nerbudda river at Sacur	100
To the summit, west of Belhari	80
To the fork of the Sone river	55
To the mouth of the Goput river, near Burdeo	90
To the mouth of the Coyle river (Palamow coal-field)	100
To the summit east of Gaya	100
To Oberah, between the Danwora and Hadji rivers, in the centre of Burdwan coal-field	110
To Burdwan	46
To the right bank of the Hooghly river, opposite to Calcutta	54
Total	1,165

68. And for the causes before assigned for augmenting this distance, on account of probable circuits that may be found necessary in order to evade particular difficulties, or to obtain easier rates of ascent through the Ghauts, this should be called 1,250 miles, which, at the average rate of £8,000 per mile for a single line of railway with passing places, but prepared for a double road, will require the sum of ten millions sterling, which may be considered a minimum sum, as sufficiently explained in the first pages of this statement.

69. If the more circuitous line by Surat and Broach, and along the entire course of the Nerbudda river, be adopted, the itinerary would be as follows, namely:—

	Miles.
Bombay, through the island of Salsette	25
Thence to near Damoora	75
To the Taptee river, near Surat	60
To the left bank of the Nerbudda, east of Broach . .	40
Along the Nerbudda valley to the Gunial river, east of Hindia	280
	480
Thence to Calcutta by the former route	805
Total . .	1,285

which, with the addition for probable detours, will make an increase of about 100 miles over the other line.

70. For the purposes of a railway across the Indian continent, between Bombay and Calcutta, such a circuit becomes only the question of a few hours; and, postponing a comparison between the two routes, it may first be inquired whether the communication to China may be advantageously extended from Calcutta.

71. Looking forward to the vast and increasing importance of establishing the most certain and expeditious connection with the Chinese territories, over which a dominating influence, at least commercially, must henceforth be established by Great Britain, the passage across the Isthmus of Malay from the Mergui archipelago to the Gulf of Siam, before alluded to, will probably form a portion of the future line of communication. In this case, if the railway from Bombay to Calcutta become included therein, it will be seen by the following abstract of distances, as compared with those given in a preceding page, that the advantage in time at least would just preponderate over the route proposed by way of Masulipatam:—

SEA and OVERLAND ROUTE, from the Red Sea to China, by Bombay, Calcutta, and the Siamese country.

		Miles.
Socatra to Bombay	.	1,400
Bombay to Calcutta	.	1,300
Calcutta to Mergui	.	1,000
Across the Siamese country	.	100
Gulf of Siam to Macao	.	1,600
Miles	.	5,400
Deduct land journey	.	1,400
Sea voyage	.	4,000

72. Thus it will be perceived that by such a line the length of the sea voyage would be reduced 1,200 miles out of the entire course from the Red Sea to China direct, by the south of Ceylon and Singapore; and, although 200 miles are added to the geographical distance, yet computing by hours, which steam has taught us to do, and taking the rate of railway to sea—steam traveling as 3 to 1—there will be an advantage of nearly four days in time; and, considering that the monsoons would not affect the voyage between Calcutta and Mergui in either direction, two or three days more may be reckoned upon. As compared with the present arrangement which makes the long circuit round the Indian peninsula by Bombay, there would be a positive gain of upwards of a week, but as contrasted with the route of Masulipatam, the advantage however would not be more than one day.

73. Admitting the passage across the Siamese country not to be carried into effect, the abstract of distances by Calcutta would be thus:—

		Miles.
Socatra to Bombay	.	1,400
Bombay to Calcutta	.	1,300
Calcutta to Singapore	.	2,000
Singapore to Macao	.	1,600
Total	.	6,300
Deduct land journey	.	1,300
Sea voyage	.	5,000

being an increase of 1,000 miles of sea-going route. Still, computing by time and not by mere distances, the correspondence and intercourse would be equally accommodated as by the other competing lines, for, compared with direct voyage from Socatra by Ceylon, there would only be the difference of a day, or at most two, which the advantage of not encountering the monsoons between

Calcutta and the Straits of Malacca, either going or returning, would very much more than compensate for, and, as opposed to the present mode of communication, there would be an actual saving of two or three days.

74. The itinerary by Masulipatam, if the shortening by Mergui and the Gulf of Siam were not effected, would be :—

	Miles.
Socatra to Bombay	1,400
Bombay to Masulipatam	700
Masulipatam to Singapore	1,900
Singapore to Macao	1,600
Total	5,600
Deduct land journey	700
Sea voyage	4,900

75. This would give an advantage of half a day of sea and a whole day of land journey to the Masulipatam line; but it may be readily granted that the importance of having a direct means of correspondence between China and Calcutta, on the great chain of communication between eastern Asia and western Europe, may be well placed as a set-off against this, the only one of so many various directions in which a very small preponderance of time can be found, over the contemplated overland route through the Bombay and Bengal presidencies.

76. The only drawback to this arrangement of railway and correspondence is, that the trade and presidency of Madras are altogether excluded; nor is there any possibility whereby it could be embraced in any general system except by the Masulipatam line. Indeed the advantage this latter route presents to Madras is probably one of the greatest arguments in its favour. Still, looking at the larger contemplated measure in its evident range, it must be admitted even by those most interested in the prosperity and advancement of the Carnatic, that it is impracticable by this one line only to extend to that portion of the country the advantages which such a line must bring to almost all the rest of India; and it can only be hoped that the success of the proposal herein suggested may be the means of stimulating exertions that will terminate in forming a great south-eastern trunk railway from Bombay which would not be longer than that to Masulipatam first discussed.

77. If the principle of establishing railways in India be taken up as great national undertakings, either directly by our Government and the East India Company, or in connection with and in

aid of high-minded individuals, united in one or more private associations, there is no doubt a railway to Madras, as well as one to the north-west frontier of India, will thereafter be established. Although Madras and its dependencies could not, for the present, be included in the great series of intercommunication, another district would have advantages and facilities extended to it of which it is now in want, and which may produce most valuable results.

78. The new and important colony and fine harbour of Amherst, and the adjacent town of Moulmein, in the Gulf of Martaban, near Rangoon, and the mouth of the Irawaddi, and also the settlement of Mergui, would be put in direct connection with this country even if the line across the Tenasserim province to the Gulf of Siam be not made. A rendezvous station between Calcutta and Singapore, for the steamers to communicate with Amherst and Mergui, might be established at Narcondam island, which is visible at a distance of sixty miles round its horizon, and lies in the direct track.

79. The high-raised expectations, already in course of realization, of the prosperity of these two settlements, and the great commercial advantages rapidly developing therefrom, merit the boon which a line of intercourse thus brought to their shores would afford; and though it is far from being assumed that this could be accepted as any compensation for not serving Madras, yet as that cannot be done, at any rate it is at least well that such thriving colonies as Amherst and Mergui can have a benefit like this bestowed on them. Before quitting this subject it may be noticed that there exists every reason to believe that a road for elephants and wheeled carriages formerly existed between Mergui and Banguaroon, the plain on the west side of the Gulf of Siam, where the steam-packet station has been contemplated for forming a more direct communication with China by Macao, from which it is distant little more than a week's steaming.

80. Having thus, it is submitted, satisfactorily established the fact, that a railway between Bombay and Calcutta will be the best and quickest mode of communication between England and China, let the local advantages of this line be the next point of inquiry. It seems needless to repeat here the general arguments adduced in reference to the line from Bombay to Masulipatam, since they are strictly applicable to this projected substitute, which pervades in a north-east direction, provinces more rich, more fertile, more salubrious, and more under the control of Great Britain. Details are impossible in this present stage, but abun-

dant general information is extant to show what capabilities now exist, when fair means of development are presented; nor must the sources of traffic be supposed to be confined to the mere line of railway or to the closely adjacent country. If, at present, the merchant transports, at heavy cost and risk, the productions of Candeish, Aurungabad, Berar, Malwa, &c., many hundreds of miles by the rudest means, to Bombay in the west, or to the Ganges in the north, thence to descend many more hundreds of miles to Calcutta, what may not be expected when the railway, pervading the land like a mighty river, will offer at every station a market, or, at least, a point of embarkation for the collected produce?

81. A lateral transport of one or two hundred miles to attain the railway is comparatively trifling to what has to be traversed at present. Even at an increase of 50 per cent. upon the prices quoted as the proper mercantile railway charges, produce could be brought from any part of the districts thus penetrated, either to Calcutta or to Bombay, at less than 1*d.* per lb.—including the cross-country carriage—to the railway, and from most of the richest districts at half that cost. With the economy and rapidity for moving over the country afforded by the railway, and with the facilities for collection and inspection, the frauds in packing so bitterly complained of, the neglect in cleansing and preparing, the errors and prejudices, and the attention to less useful articles of culture will all be removed. The monopoly possessed in so extraordinary a degree by that remarkable class of traders and their agents, known under the general name of 'Marwarries,' will be broken through. The 'Ten Photodars,' as they are called, who have the command of the markets in every bazaar, from Bombay to Calcutta, and from Delhi to the banks of the Krishna—over nearly a million of square miles—will find watchers of their frauds in collection and distribution, and rivals in their business at every step, when a few hours will convey the English merchants or his active representatives, to any of the many stations on the railway, whence the most distant mart would be speedily attainable.

82. The direction between Bombay and Calcutta will be easily regulated in its details, as any minor deviations will not affect the great bulk of traffic; and until further progress in this investigation is made, the general course pointed out as going direct from Bombay to the valley of the Nerbudda may be assumed, if such direct route be, under all circumstances, preferable; and from the Nerbudda the line passing along the extensive coal and iron

fields, and approaching the great commercial and military ports and populous cities in the provinces of Allahabad and of Berar, will combine, in its course, most of the favourable points which generally influence the selection of a railway. There will then only remain to investigate the various circumstances which might lead to making the grand detour of the line on the western side of India which has been before mentioned.

83. In reference to this question, it should be observed, that a distinguished military officer, in the service of the East India Company, left England very recently on his return from a visit to London, made for the purpose of collecting the best materials to enable him to form an estimate of the probable cost of forming a railway from the farthest north-west port of the Bombay presidency at Deesa, near the head of the Gulf of Cutch, through the province of Ajmeer, by Balmair and Jessulmair, and across the desert of Sinde to Bukhur on the Indus, near the great commercial Affghan city of Shirkapoor.

84. Assuming that such a communication is called for and much wanted, as will indeed be shown, then it may be inquired whether a certain extension to the south from the suggested line, as far as Broach, might not be a weighty argument in favour of turning the main trunk of railway from Bombay to Calcutta to meet it. Suppose this to be done, and the lines all completed, then, casting a glance over the map of India, how forcibly we must be struck with the powerful union effected throughout Hindostan by such a series of railways, especially could the south-east line to Madras be included within this system!

85. From Bombay to the banks of the Nerbudda river, near Broach, would be 200 miles along the principal line; from this place Calcutta is distant about 1,000 miles, and the nearest point on the Ganges by railway—being in the vicinity of Allahabad or Mirzapoor—is within 700 miles. From Broach to Deesa is 180; and from Deesa to Bukhur about 320 miles, thus making the north-west branch to the point of safe and uninterrupted steam-boat navigation on the Indus 500 miles. The station at Bukhur being thus distant, in time—by means of the almost talismanic railways—three days from Calcutta; two days from Allahabad; one and a half from Bombay, and about three from Madras; Bukhur being also only about 500 miles, or two days' steam-boat journey, from Attock, Lahore, and all the other points at the heads of navigation on the five great branches of the Indus.

86. The real difficulties against duly profiting by the opening of the important river all lie below Bukhur, from the continued

changes of its course between that place and the sea, and from the dangerous ever-shifting channels and shallow waters at the mouths of its Delta. Above Bukhur the navigation is clear and open up to those towns now unhappily the seat of war, but which it is hoped will soon be over and give peace to only peaceful emporia of commerce.

87. What a host of ideas arise in the mind at the mere suggestion of the grave and probable adoption of such a combination as would place these remote points of India within as many days as they are now almost months distant from the centre of our resources, and that not simply for despatches, but for armies and all their 'matériel!' What a contrast of the capability presented of rapidly transporting supplies of troops and munitions of war, compared with the trains of camels traversing the desert, each with a cannon-shot swinging on either side, or with the sickly march of the jaded and spirit-broken Sepoy!

88. The cost of such a branch railway from Broach, by Deesa, to Bukhur and Shirkapore, with the extra expenses incurred in taking the detour by the estuary of the Nerbudda, would be covered by five millions, which, with the charge for the line between Bombay and Calcutta, is an aggregate of sixteen millions sterling, or as many crores of rupees; and well-informed persons have asserted that such a sum would barely cover the expenses of the Affghan war!

89. But peace restored, such a railway would be advantageously employed in taking merchandise for the natural wants of the countries beyond the Indus and Sutlej. These require to be supplied with the metals and manufactures of England, the silks and indigo of India, and the teas and spices of China and the Eastern islands, of all which articles large quantities are consumed. In return, from the Punjaub cotton and sugar, crystal salt, saltpetre, &c., might be exported to any extent. From Mooltan, tobacco of the finest quality in the world. Almonds, raisins, currants, and groceries (already supplying all Upper India) from Cabool. From Affghanistan, through Shirkapore, oils, drugs, dye woods, &c., and assafœtida, used greatly in all parts of the world, but throughout India as a daily condiment. At present the trade is carried on from Bombay by coasters to Bhownuggur—a small port on the north side of the Gulf of Cambay—and thence by canals to Palee as a central point, branching from thence to Shirkapore and to Amritzer, near Lahore. English piece-goods, tea, spices, cochineal, indigo, quicksilver, &c., are sent through at a cost of 7*d.* per lb. to the latter and 6*d.* per lb. to the former place, the time occupied being two months and six weeks

respectively; this is at the rate of about 1*s.* per ton per mile, including the sea voyage; the canal traffic costing 18*d.* per ton per mile.

90. From Calcutta spices, metals, &c., are sent nearly 1,000 miles up the Ganges or the Jumna, and thence carried by hackeries 400 miles to Amritzer, at a cost of from 2*d.* to 3*d.* per lb. for the entire distance from Calcutta, of which the river freight is not less than 2*d.* per ton per mile, and the hackery charge about 8*d.* per ton per mile; the period of transit between Calcutta and Amritzer occupying nearly five months.

91. With all these disadvantages of expense and delay in transit, the annual value of the Bombay exports to Amritzer, with 350 miles of sea and 800 miles of land-carriage, is officially stated at half a million sterling, of which one-fourth is in English piece-goods; and to Shirkapore, about £50,000 sterling. The value of the exports from Calcutta to Amritzer is about £150,000, with 1,000 miles of water and 400 miles of land-carriage.

92. With the facilities of a railway route to Bukhur, and steam-navigation on the rivers, certainty, regularity, and great economy of carriage must ensue, and especially would an opening be made for receiving the produce of the country in exchange for the imports —for want of all which there is a great limit to the consumption of English piece-goods, metals, &c., &c., these being now considered great luxuries, but which would hereafter become articles of general use. And it must be again remembered, that it is only by our taking in exchange the natural productions of Upper India that the inhabitants can afford to buy our manufactures. It would seem, from the latest accounts, that it is almost hopeless to navigate the Indus below Bukhur with success; the railway is therefore the only resource; and there can be no reasonable doubt that the increased trade and facilities will repay the cost, if brought within the amount stated, of which satisfactory assurances can be given. A great deal of valuable information on this head is to be found in the Report of the Chamber of Commerce of Bombay, for the fourth quarter of 1839-40, dated in September of the latter year, particularly in the notes of Colonel Ward.

93. In recapitulating the lines of railway which might be advantageously opened in India, we have in round numbers the following:—

ABSTRACT OF DISTANCE AND EXPENSES.

DISTANCE.	Miles.	Sterling Money.
		£
Bombay to Masulipatam	700	6,000,000
Bombay to Calcutta (say about)	1,300	11,000,000
North-west branch to the Indus to include extra cost of detour of Calcutta by Broach	500	5,000,000
South-east branch from Bombay to Madras, as a substitute for the Masulipatam line	700	6,000,000
Total miles . .	2,500	22,000,000

94. The execution of the entire of this system would probably be too great for private enterprise—certainly so without the direct aid, and perhaps the participation, of Government and the East India Company. Yet it is, at any rate, desirable to keep the whole in view; and to whatever extent individual and associated speculation may deem any portion of it worthy of being undertaken, a general and comprehensive system, such as above developed, should be laid down from the commencement; to be followed out, at once or by degrees, as circumstances may admit. Granting that it can be satisfactorily shown—and it is deliberately and conscientiously undertaken to be so demonstrated—that twenty-two millions sterling could effect the whole, or 'pro ratâ' for whatever distance executed; and that three shillings per train mile would cover all expenses, it becomes easy for the merest tyro in Indian statistics and its political and military movements, to determine whether there does not exist the very best grounds for believing that a reasonable interest on the expenditure may be depended on by the capitalists, without taking into account the advantages to the nation of a henceforth secure tenure of the frontier, and of all our interior possessions, or of the improvements certain to follow by colonisation through all the districts pervaded, and far beyond them; giving European example of what may be extracted from the soil, which the most prejudiced and most apathetic of the native possessors and cultivators will not fail to follow, and for want of which example it has been observed that, "the Indian cultivator must at present literally be bribed to his own advantage."

95. It is presumed that enough has been made out to justify those who are sufficiently interested in, or may be 'à priori' disposed to take up this important subject of railways in India, in going

into a more detailed investigation, which may be likely to lead to some practical result. A survey will in some shape be necessary, and various authentic returns, which may probably only be satisfactorily obtained in India. If the line to Masulipatam be preferred, the task will be shorter and more simple. If the bolder and more comprehensive measure of the Calcutta railway be chosen, or only one or more portions of it, a decision will be first required on the direct or the circuitous line between Bombay and Hoshungabad; and the greatest consideration will have to be brought to bear on the solution of this important question. Hereafter it may not be unreasonable to suppose that both lines may be constructed; but, as the first step, a choice must be made between the two, which will of course be swayed by the part taken by Her Majesty's Cabinet and the Court of Directors of the East India Company. This leads to the point where the matter ceases to be debateable on private considerations, and leads to an attempt being made to investigate it wholly on great public grounds.

96. Without observing further on the policy of the East India Company, it may be remarked, that little or rather nothing has been done by them for India for the true development of its resources; since easy means of internal communication—the very first step necessary to effect this object—have never been attempted until very recently indeed; and were the whole projected system of railways unconditionally undertaken by the Company, it would be but a tardy fulfilment of long-deferred obligations which their claim of seignorial dues on the land requires of them. That "property has its duties as well as its rights" is equally true in India as in Ireland; and quite irrespective of the political colour which was given to that aphorism. As has been observed by an eloquent writer in India, in a valuable but fugitive report, "Improvements "are the bounden duty of a government which claims the landlord's "right of property of soil, and leaves the great mass of the inhabi-"tants no higher objects of *amor patriæ*, or claims from that govern-"ment on their patriotism, than the limited gratitude of a rack-rent "tenantry: the doctrines of political economy, though true as mathe-"matical demonstrations, apply not in cases where the native ener-"gies of the people lie crushed under the most debasing of all "superstitions, and the most exhausting of all systems of taxation."

97. So sensible of the value of better and improved roads have been the best informed resident officers of the East India Company, that, a few years since, it was proposed by them that five per cent. of the revenue of the country should be appropriated to its general internal improvement; and the principle of such a measure was

fully admitted by the late Sir Robert Grant, the enlightened Governor of Bombay, who only so modified the idea as to suggest a smaller percentage. The establishment of a distinct Department for Roads in the Bombay Presidency about seven years ago, under a competent Engineer; the operations since conducted by him, to the aggregate amount of about £50,000 sterling; and the late suggested improvements in the navigation of the Nerbudda river, all prove that the principle, at least, of the East India Company attending to internal improvements is fully admitted, and was acted on; though it is to be lamented that courage has hitherto been wanting to carry this principle to a sufficient extent, or to mete out the full measure of justice due to the country, and to lead to a development, not only of its commercial and agricultural capabilities, but to effect its military security.

98. Taking one million as the annual amount for interest and sinking-fund to be charged on land revenue, in addition to the railway profits, surely the credit of the East India Company could raise in a few hours the necessary capital. This will practically be the same as one of the plans proposed for obtaining money to make railways in Ireland, of which the leading feature was to be an extension of the credit of the State to the counties, on the security of the local resources. Why not, therefore, at once raise the money by an Indian Railway Loan on Long Annuity Stock, secured on the land revenues of the particular districts of the country to be pervaded and benefited; or by many of the financial contrivances well known in the London Money-market? The security to the investors is undoubted; the risk to the undertakers nothing; the amount of immediate benefit, in an agricultural, commercial, fiscal, military, material, and, in short, every point of view, almost beyond bounds of expression.

99. India, under railway aspects, greatly resembles Ireland in many respects, and the weighty reasons adduced in favour of Irish lines seem to present themselves naturally to the mind while contemplating Indian railways; and the following arguments, hastily blended, are but the echo of what was written and urged in all quarters at the time in favour of operations in Ireland, and which come, happily, to hand and are easily applied, *mutato nomine*, to India:—

> "As far as one or two principal lines go," wrote the powerful pen of the Editor of the *Times*, "railroads are " perhaps the most useful mode in which public money could " be expended in *India*." "A nation," observes a writer in the *Athenæum*, "*may wisely spend money upon other considera-*

" *tions than those which govern a private capitalist.*" "We know " not, indeed, how the trading house of Great Britain & Co. " could lay out money to a greater advantage than by " bringing its *Indian* resources into full operation." *India* " is a farm in the worst possible condition ; out of heart and " unprofitable. In such cases the wise man applies his " other resources in the work of amelioration ; *he advances* " *his capital on the prospect of remote but certain returns.*" " Time does wonders : the Report " (on the *Irish* Railways) " will at least contribute to hurry on events, by the know- " ledge of the details which it will disseminate. In adding " the unit of our own convictions we do our duty as journal- " ists and ease our hearts as men. We repeat, then, that " the project of a grand and comprehensive system of rail- " ways for *India* is a godsend to the cause of humanity, of " peace, and of national prosperity."

100. The admirable section (of the Irish Railway Report) "*On the influence of Railways in developing the Resources of a Country,*" contains a multitude of statements calculated to inspire the firmest hopes of the success of those works in *India* :—

> " We have direct proofs " say the (*Irish* Railway) Commissioners, " that *India* is as capable as other countries of being " influenced by the same cause and of profiting by its ope- " ration ;" and they add forcibly : " and there is this addi- " tional motive to recommend the subject for consideration, " that the backward state of the country presents *a stronger* " *obligation, as well as a wider scope* for improvement. Past " misgovernment and neglect have certainly left an ample " field for exertion in *India ;* and decidedly the moral obli- " gation to commence the work of amelioration grows " stronger every hour."

101. And how inexpressibly applicable to India are the follow- extracts, also from the *Athenæum :*

> " From the prosperous results that have followed other " projects that have from time to time been undertaken, to " better the state of *India*, the fairest auguries are to be " drawn for the enterprise now recommended. In every " case where a new ordinary road has been opened through " districts before impervious, an increase of traffic and inter- " course has been the uniform consequence, by extending " the field of industry and contributing to the tranquillity " of the country, by opening and facilitating communication " through tracts where guilt and outrage had previously

"found secure asylums." "Results equally happy have "attended other undertakings, proving the aptitude of *India* "to profit by all the efforts of public or private enterprise, "to develop her resources and give her energies employ-"ment. The regular establishment of steam navigation "upon the principal rivers and along the coasts of *India* has "given to mercantile and general social activity a vast "impetus. Not only have old branches of trade been ex-"tended, *but nine-tenths of the traffic at present carried on is* "*new*. That a well-arranged system of railways would have "the effect of continuing and extending through the country "the advantages which the outports have thus obtained by "the introduction of steam-vessels seems to be indisputable. "In fact, in the present state of commerce *the railway is an* "*exigency of the country*—one of the principal wants of *India*. "Perhaps we might lay down a general proposition, and say "that *a railway is a corollary from a steam-ship*.

102. "Upon the moral effects of the extended intercourse "likely to take place between England and *India* in conse-"quence of increased facilities of travelling in the latter, "considerable stress is very properly laid. Most true it is, "and not more true than deplorable, that *India is very little* "*known to the British people*; nor can we imagine any better "means of promoting that most valuable of useful informa-"tion (in fact, it is self-knowledge) than the execution of a "great system of public works, forming an easy and rapid "mode of communication throughout the country. Bacon, "in the '*Advancement of Learning*,' interprets the texts in the "prophet Daniel, '*Many shall run to and fro, and knowledge* "'*be increased*.' Of the effects to be anticipated from the "progress of nautical adventure, and what he calls the "'openness and through passage of the world.' With how "much more force would this application of the prophetic "words have struck our great philosopher, had he seen the "steam-ship and the railway! *Multi pertransibunt!* may "well be exclaimed of these days of ours; and yet we see "but the infancy of these mighty instruments of civilization "and enlightenment. The steam-ship was the first bond of "real union, thorough and indissoluble. Most truly observed "the French Minister of Public Works, in a late address to "the Chamber of Deputies, 'Railways are, next to the in-"'vention of printing, the most powerful engine of civili-"'zation that the ingenuity of man has ever devised. It

" 'is difficult, if not impossible, to foresee and define the " 'results, which they must of necessity at some period pro- " 'duce on the fate of nations.' "

103. And another writer, acting on a different line of politics and principles, says:—

" We have no hesitation in expressing our decided and " deliberate opinion, that to a country circumstanced like " *India*, such an expenditure of the national funds should be " the first duty of the Government. The tolls upon the " principal *railroads* we have no doubt would abundantly " repay the expense of construction, and the indirect returns " to the Government in the general improvement of the re- " sources of the country, is incalculable. So far as these " principles go, we believe there can be no controversy or " even a difference of opinion. We can conceive, indeed, " no more noble enterprise for the British Government to " engage in than that of constructing railways through " *India* at the national expense. *We have ever believed the* " *great fault of all British Governments to have been a niggard-* " *liness of expenditure in undertakings like these; and we say this* " *in the face of the many magnificent undertakings which even in* " *India have been accomplished by Government.*

104. " We hold that the best, because the most practical, " view is that which assumes, in the first instance, that the " construction of railways under any system, being a *good*, " we ought not from any foolish preference for either " Government interference or private enterprize, in the " present circumstances of *India*, to reject any feasible " prospect of *seeing that good accomplished.* But it is clearly " the duty of the Government, and the interest of the public, " that whenever private enterprize is willing to execute a " railway from one place to another, every facility should be " afforded by the State, unless Government are ready to " supersede its efforts by constructing the proposed railway " at the public expense."

105. On general principles, and as applied to free states, a Government ought not to interfere with any enterprize that might otherwise be entered into by associations of individuals; but when, from the magnitude of the undertaking, private enterprize shrinks from the task, and when the Government is at the same time owners of the soil, it stands in the position of a simple proprietor. Or, even if that were not the case, Government aid should be extended when the condition of the country is such that in respect of

advancement—as regards the surface only—from a state of nature, as in *India*, it may be said scarcely to have gone a step, yet, having the population advanced considerably in all the arts and usages of civilization, imbued with skill and industry, but without capital.

106. In such cases, though a particular work may be executed by individual enterprize, a great system of internal improvements such as the railways contemplated, might be best effected by the State. Rules laid down in this respect for England are not applicable to *India*. England is chiefly engaged in mineral, manufacturing, and commercial pursuits; and those who follow agriculture generally do so on a large scale, and on scientific principles, so that the productive effort of the well-fed skillful labourer, on a soil of a much inferior quality, is greatly more than what it is in *India*, where the largest body of the population have scarcely any employment but agriculture, followed, not as a pursuit based on capital and executed with skill, but as the means of procuring to its inhabitants this stinted daily allowance of food of the most inferior kinds; and whereby—it may be added—from the peculiarity of the climate and seasons, and, above all, from the want of any sort of economical means of transport, the wretched people are often scourged by famine.

107. The preceding are the substance of some arguments in the *Dublin Review* in reference to railways in Ireland, and the same writer says:—

> " The advancement of England to its present state of
> " improvement by the energies of individuals, and the
> " combined skill and pecuniary resources of associated bodies
> " of capitalists, is the aggregate result of the labour of two
> " centuries."

In several of the American states, particularly that of New York, they have been advanced vastly in the scale of national importance and prosperity—too often, alas, from the outlay of unrepaid English capital—by the creation of numerous links of intercommunication—chiefly, however, under the direction of the state governments—effecting for that country within five and twenty years a development of resources unparalleled in the history of interior ameliorations; a result which can only be compared to—what may certainly be predicted—the consequences of the improvement of *India*, an example which our Government have followed in Canada by the construction of the Rideau Canal, and which must be followed out in India by the adoption of the railway system if the Government wish to advance—at a pace equivalent to the move-

ment on those lines—the improvement of these fertile districts, instead of allowing them to crawl, walk, ride, wagon, canal, and coach themselves through centuries of difficulties, to that stage of improvement to which they might at once attain, almost by a stride, by proper aid from the Government, indirect, at least, if not more decisively, extensively, wisely, and directly afforded:

> " Since" (to repeat the most expressive language of the Irish Railway Commissioners, and here applied to *India*) " it " is a waste of the public available resources to suffer a large " portion of the empire to lie fallow, *or to leave it to struggle,* " *by slow advances and with defective means,* towards im- " provement, when the judicious aid of the State might at " once make it a source of common strength and advantage."

108. In the words of a writer in one of the quarterly periodicals:—

> " *When society would derive a vast benefit from any public* " *work,* which private interest might not consider a suffi- " ciently tempting speculation, or might not possess the " means of accomplishing, we hold it to be the part of " Government, which represents the general interest, to be " the undertaker. We apprehend this has been the case of " *India* for many a day, and we have already shown that the " community have profited most amply by the little in the " way of public works which the Government have effected " in that country."

109. Ten or eleven years ago a Select Committee of the House of Commons, in considering the post-office communications, thus reported:—

> " Every new communication which shall be opened will " open new districts for the employment of capital and the " increase of industry; a new market for the manufacturer, " a new supply of food for the artisan, and a new source of " revenue for the State. Every improvement of lines of " communication will tend to induce the capitalist to settle " in the more remote parts of *India*, and thus spread industry " and happiness in those hitherto neglected districts; civili- " zation and employment will extend; and disturbance, and " the cost of putting down disturbance, will be got rid of. " The Government should recollect that it is peculiarly an " English object, that the most remote parts of *India* should " be connected as intimately and as closely as possible with " herself, that this object will be mainly effected by opening " to every part of that country the most direct and easy lines " of communication with England."

110. And an eloquent anonymous writer on the same subject says:—

"Facilitate the intercourse between the two countries; " connect not only *India* generally, but also her *remote parts*, " as intimately as possible with England, and without in " reality changing the distance of places, we shall in effect " bring all not merely within the influence of each other, " but within the influence of the executive; giving to each " the advantages of both; compressing the whole of the " countries, as it were, within the circuit of a few *days*. We " shall thus introduce into *India*, not only the muscle but " the *mind*, the *enterprize*, and the *security* of England; im- " parting to her new life, new feelings, new objects, and " new interests. Ingenuity and capital will have an *un-* " *disturbed* and peaceable scope to improve where Nature has " been so superabundantly beneficial; agriculture will ad- " vance, manufactures flourish, science employ her genius, " and talent, industry, happiness, and civilization extend. " Railways and steam are indeed effecting a new econo- " mization of life, of business, of government, which neither " ignorance can stop nor interest interrupt; they will be the " great degenerating powers of *India*. The more the case " is considered, do advantages, benefits, conveniences, and " accommodations multiply. It opens to *India*, as it were, a " new world, and discloses her resources to the enterprise " and public spirit of England."

111. And in his evidence before the committee of 1835 on public works, the writer of this report said:—

"All experience shows that any expenditure of money on " public works had invariably introduced comfort and peace " to the labouring population, and had increased the public " revenues in direct proportion to the amount of money ex- " pended. Of such public works railways stand first, pre- " senting *the mode of communicating by land with steam* which " by sea and by river has been so beneficial to *India*. Rail- " ways possess extraordinary claims on the Government from " their efficiency as instruments of agriculture, commerce, " and military defence, and as conducive to prosperity, " wealth, and peace; claims more apparently paramount as " regards *India*."

112. After so many quotations from various writers on a subject so analogous, indeed (almost) so identical with that of railways in India, it must not be considered supererogatory to conclude with a

few direct extracts from the second Report of the Irish Railway Commissioners, bearing forcibly and remarkably on the introduction of a general railway system into any country; and the most casual perusal cannot fail to impress the reader with the curious and extreme applicability of the carefully digested remarks of the distinguished authors of that valuable document to the object propounded in this statement:—

113. " Experience," say the Commissioners, " testifies that " increased facilities of intercourse between distant places, " and *more especially between sea-ports and the interior of a* " *country*, are among the most effective means of extending " civilization with its attendant lights and benefits. *Together* " *with the opportunities of communication, a desire to take advan-* " *tage of them is diffused*, and the important results to be " expected will follow more promptly, in proportion as the " means thus presented shall combine security with con- " venience and despatch with both. The proofs and in- " stances which sustain this assertion are not confined to " the case of any one country or district, although they are " more observable in communities where the resources of " wealth and commerce already possessed by the inhabitants " made them to turn every advantage as it arises to imme- " diate account."

114. " In countries less forward the ability to profit by " the occasion does not at first exist, especially among the " lower class, but must be acquired by degrees; consequently " improvement also will be *gradual*, and though more tardy " in its first manifestations, is not eventually the less certain " and striking. The extent to which intercourse is not " merely promoted, but actually *created*, by the facility of " accomplishing it would, however, be scarcely credited, but " for the numerous and authentic examples which establish " the fact."

After quoting many very remarkable examples of increase, particularly that in Belgium, which has been *twenty-fold*, and commenting on the extraordinary traffic of passengers moving very short distances at the lowest fares, a fact is stated which seems peculiarly applicable to India:—

" When the Erie Canal in America was commenced, there " were not, over its vast extent of many hundred miles, more " than fifty small villages within a distance of twenty miles " on each side, whereas, ten years after its completion, there " were one hundred and thirty villages exhibiting daily

" residence of prosperity and wealth, besides numerous and
" well-cultivated and well-stocked farms."

115. Having alluded to the American railways, it is stated, from official documents, " that the railways completed in the United States up to the 1st January, 1835, extended 1,600 miles in length, and their cost was £8,130,000 sterling;" being only about £5,000 per mile. One of the most expensive lines, as has been previously stated and analysed, having little exceeded £8,000 per mile, which sum has been assumed herein as the average of the cost of railways throughout India.

116. " A well-arranged system of railways" (the quotation is again from the Commissioners' Report), " would " have the effect of continuing and extending throughout " the country the benefits which the outports and river " towns have obtained by the introduction of steamboats. " It is scarcely necessary to dwell upon the great and " obvious advantages that would result from such combined " facilities of intercourse. The subsisting relations of " business and commerce would be thereby extended and " enlarged, and others formed, opening fresh resources to " the industry and enterprise of the trading portions of " the community, while an object of no less consideration " would be immediately attained in rendering agricultural " produce the great staple of the country, at the same time " more profitable to the producers, and accessible on easier " terms to the principal purchasers and consumers. An " opinion, which we believe to be quite erroneous, has become " prevalent, that because in populous and wealthy districts " in which railways have been established, their traffic has " consisted for the most part in the conveyance of passengers " and goods of high value, they are therefore ill-adapted " to the conveyance of goods of bulk or of ordinary value. " We cannot, however, see any reason to doubt, but, on the " contrary. we can see good grounds for calculating on a " great extent of profitable traffic in agricultural produce " as well as in other articles.

117. " It would be an endless task to point out the " various interests and social relations which would be " more or less affected by the introduction of this mode of " traffic on an extensive scale; but it is very proper, " before we conclude this point of our subject, to advert " shortly to its probable effects upon some departments of " the public service. Of these the post office naturally

"first presents itself to the mind. The vast importance "of the transmission of letters needs but to be mentioned. "There is not a merchant or man of business who cannot "readily appeal to instances of the great value of even a "few hours saved. We may contemplate as another "example the effects on the military service of the country; "the facilitating of the moving of troops in large bodies "over hundreds of miles in a few hours, fully supplied with "artillery and stores, and in a state of perfect readiness "either to oppose foreign aggression or repress domestic "outrage, must be apparent, and its influence can scarcely be "overrated. But it is needless to multiply instances of "the application of this principle, as far as its powers have "been ascertained, to the actual concerns of the country, "and it would be folly to attempt to impose limits to its "future influence in creating new resources for its popula-"tion or in giving directions, as yet unknown, to those "already possessed. The mind can scarcely set bounds "to the extent to which the effects of so important a dis-"covery may be carried, nor the imagination take too wide "a scope in speculating on its future operations. What "has been already done upon its very threshold, and, as it "were, in the dark, seems but an earnest of advantages to "come when experience shall have shed its full light upon "the subject and brought this wondrous power still more "within the grasp and command of man."

118. And it is desirable to state on the authority of the Irish Railway Commissioners:—

"*That it would completely frustrate most important objects, and* "*oppose a bar to future improvement, if those portions of railway* "*lines which hold out special objects of advantage are alone* "*undertaken or monopolized by isolated companies*—such, for "example, as the first sectioning out of the great towns" [Bombay, Calcutta, &c.] "over which all the traffic with "other places, near as well as remote, must of necessity pass, "*for it is manifest that if the best and most productive portions* "*are taken possession of unconditionally, there can be no reason-*"*able hope that the remainder will ever be carried into effect.* "*It would be even more advantageous that no part of the line* "*should be sanctioned until the country should possess within* "*itself the means of undertaking the whole system to its full* "*extent, than at once and for ever to obstruct and paralyze all* "*future exertions for its accomplishment by abandoning the*

"*portions having particular and distinct interests*, the monopoly
"of some of its most productive detached portions. *It is*
"*essential for producing the greatest national advantages that*
"*the gain on the more profitable parts should be available to bear*
"*the loss of others of deficient revenue*; provided only that in
"the whole a fair remuneration for the capital invested can
"be derived from the undertaking."

119. It will be manifest how importantly this principle, which has already been propounded in an antecedent part of this statement, bears on the enforcement of the railway as an entire and comprehensive measure as between the two capitals of Bombay and Calcutta, and that notwithstanding its greater length and cost, it must, in addition to being free from many of the objections to which the Masulipatam line is liable, be, from the very fact of the number of large places of great local traffic embraced, much more likely to be remunerative. Still, even with this aid, and with the advantages of pervading the great coal and iron fields, it is obvious that over many districts, and those probably when the cost of construction would be greatest, the traffic would be least. Consequently, to insure the great fruits of a perfect communication across India, such a connection with the great chain of correspondence and intercourse between Great Britain and China, one line of railway must be formed at all events, *in its entirety*, and thus combine the most important advantage, which cannot be too often reiterated, *of making the profitable portions pay for those which are less so*, thereby insuring the benefits of the railway to those remote and central districts, when, in the words of a fellow-labourer on those subjects, "if the pecuniary returns may not be so great, other results may be looked for well calculated to afford the highest gratification to the enlightened legislator and statesman."

120. In reference to the natural and inevitable variation in the amount of traffic over various parts of the railway between the extremities, it may not be irrelevant to observe that, in treating in a previous page on the number of trains daily, it was not intended to intimate, nor must it be assumed, that six or any other given number should necessarily pass daily over any *whole line*, as from Bombay to Calcutta, to produce a given amount of traffic, but that such extent of duty might be performed as an aggregate an not exceed the assumed expense. On some divisions of this line, five, six, or a dozen trains may leave each end per day, while in others, two, or even only one, might be required, but it is impossible in this stage of the inquiry to enter into such detail,

nor is it necessary so long as the average rate of expense per train mile over long distances, and under all circumstances, is known and can be depended on, which the facts previously brought forward demonstrate most fully.

121. Great, however, as the advantages of the contemplated railway would be to all parts of India, it is of the most vital importance to the Bengal districts, possessing as they do the largest amount of trade, carrying on the greatest extent of correspondence, and having occasion for the most frequent extent of personal intercourse with Europe and with the principal stations in India. So impressed have the community of Calcutta been with the high importance of a better connection with the mother country, that for twenty years nearly they have been supplicating for an improved communication, and especially for a direct steamship intercourse from the Red Sea to the Hooghly: liberal subscriptions to the amount of nearly £20,000 have been made—without the slightest hope of return, but merely to forward this object generally by giving a command of funds for negotiation and investigations—and to this fund native princes, merchants, and inhabitants freely and liberally contributed in common with English subjects. Is it not, then, to be expected that they will hail with acclamation a proposal that will place them within two days' distance of Bombay, and at the same time open an economical channel of communication with the interior for all the purposes of interchange of native produce and imported manufactures?

122. Nor will the English merchants of Bombay and the intelligent and wealthy Parsee traders be backward in supporting a measure securing to their port the inland traffic, which imperfect roads are driving away to a much more distant market. If, in short, the advantage of a steam connection between the Red Sea and Calcutta direct were so great as to elicit the expression from Lord William Bentinck, when Governor-General of India, "that it "would be cheaply bought at any price," although it would have left Calcutta still fourteen days farther from England than Bombay, what may not be expected from the opinion, support, and exertion of that community to a place which will practically place them on an equal footing in that respect? If the eloquent passages which are extracted below from the manifesto of the committees appointed to forward the steamboat arrangement were called forth in support of the Calcutta petitioners, the pen of the talented writer would be still more ready to support so satisfactory and complete an arrangement as now contemplated:—

124. "To India," says that writer, "England is indebted

" for wealth, for fame, and in some degree for the prominent " station she holds among the nations of the world. In " return, she has a duty to perform to the countless millions " subject to her sway—a duty which can never be performed " as it ought to be until the barrier which upholds their " mutual ignorance, and thence fosters their mutual preju- " dices, is broken down. That barrier once removed, can it " be for one moment doubted that the arts, the science, the " civilisation, the capital of England would rapidly find " their way to India? Their very nature is to extend. " They only require a road, and when that is made easy to " any place needing their presence they cannot but go. " India does need these, and England can furnish them, and " it is her duty to do so.

125. "It is her bounden duty to open wide the doors of " India for the entry and spread, *emphatically*, of the know- " ledge of Europe. It is the one thing needed in India to " enable her to advance, as, *under the dominion of England*, " she ought to do, in the scale of nations, and this can only " be done by approximating the two countries in the manner " proposed. Among the advantages to England would be " the more ready employment of capital, with consequent " extension in commerce, and the greater security of the " Indian empire, and numerous other similar benefits more " and more apparent to those who have paid attention to " the subject; and nothing would appear to be wanting to " insure a communication being established, as it ought to " be, on the most enlarged and perfect scale, but a similar " general expression of the public desire of the British " Islands, as has now been long declared through all parts " of India."

126. It is now time to draw this long Paper to a close, though not without expressing a hope that what has been adduced may lead those for whom it is intended to take some further steps in the inquiry, and afford another opportunity for going into and discussing the points of railway construction and working, estimates, returns, &c., and a variety of details generally, which it has been impossible to attempt at present. The maps hereto attached have been compiled with the kind aid of John Walker, Esq., Geographer to the East India Company, to whom the best acknowledgments are due for his extreme attention and valuable assistance. The general points herein mentioned are marked on Allen's Map of India, and the chart of the route between England

and China will elucidate the subject of the distances on the line of steam-ship transit.

127. Very great attention has been experienced from the officer of the East India Company's Library and Museum, and from the librarians of the Asiatic and Geological Societies. Professor Royle afforded the loan of some valuable reports and pamphlets; and it is only due to that eminent naturalist to refer to his invaluable work on the 'Productive Resources of India' as a fount from whence much information has been drawn, and which should be studied by all interested in the advancement of India.

128. In conclusion, it may be remarked that the great object herein has been to broach the leading principles, to analyse the principal features only of this subject, and to draw the attention of those interested, and who have originated the inquiry, to the consideration of the proper aspect in which this absorbing question, so pregnant with beneficial results to India and to Great Britain, should be considered; for, as has been observed elsewhere of the advancement of similar works for Ireland, it may as emphatically be said here:—

> "Few objects of ambition would be more honourable than "that of being instrumental in promoting a general and "comprehensive system of internal communication by rail-"way through so important a portion of the empire as "*British India.*"

(Signed) CHARLES B. VIGNOLES, F.R.S.
Civil Engineer.

(*Dated*)
London, September 22nd, 1842.

[III.—ADDITIONAL MEMORANDA

III.—Additional Memoranda as to the Swedish Railway System, by Mr. C. P. Sandberg, Assoc. Inst. C.E.

In order to show the extent of the development of the Swedish railway system from a technical point of view, the tables annexed have been drawn up. They are divided into Tables I., II., and III., and some of the figures therein are taken from official sources, such as the recently published 'Nordisk Jernbane-Kalender.'

Table I. shows the cost, gauge, and speed of the lines open for traffic, the weight of rail per yard in use, the working results for 1871, and finally the working conditions. Table II. deals with the cost, gauge, and speed of the lines actually in construction. Many new schemes are proposed, companies are in course of formation, and concessions are granted to carry out some of the projects; but they are not included in the table.

Several of the details are wanting with respect to the lines mentioned in Table II., but the results given are sufficiently numerous to arrive at a practical conclusion with regard to each kind of gauge and construction.

An abstract of the two foregoing tables is given in Table III., which may now be more particularly analysed. The railways in Sweden are divided into two classes, those of 4 ft. 8½ in. and those of a narrower gauge. The railways of the standard gauge are again subdivided into two classes, namely, those of heavy and of light construction. The narrow-gauge railways are divided into four classes, according to their widths, namely, 4 ft., 3 ft. 6 in., 3 ft., and 2 ft. 6 in.

The total lines open to the end of last year, with their average cost per mile as well as their mileage, as derived from Table I., are arranged for comparison with the speeds indicated at the head of the columns. These speeds are obtained by taking the averages recorded in the time-tables, and 50 per cent. is added to obtain a maximum, making allowances for delays, for working at lower speeds than average on up-hill gradients, on curves, and at the stations. Similar figures are given for some of the lines in course of construction, assuming the speeds at which the trains are proposed to be worked, and taking the cost as estimated. Next follows the total mileage of the two classes taken together at a mean cost per mile, from which it will be seen that there are nearly 2,000 miles of standard gauge open and in construction, as compared with about 400 miles of narrow gauge, or out of 2,400 miles of railways there are only 17 per cent. narrow-gauge lines as against 83 per cent. of broad gauge. Of these 17 per cent. 5 per cent. are unconnected, and 12 per cent. connected with the main system. The unconnected lines consist of nine separate short pieces in different parts of the country, 115 miles in all, principally used for mineral and timber traffic between lakes and mines, where sledging was formerly employed in the winter.

Thus the total mileage, when completed, of the 12 per cent. of connected narrow-gauge lines will be 258 miles, divided between eight branch lines. But at present there are only 82 miles open, and hence there is only one instance of break of gauge in all Sweden, namely, at Herrljunga.

As regards this solitary example of break of gauge from 4 ft. to 4 ft. 8½ in., the line in question has been working about ten years, and the experience derived from it must have greatly influenced the decision in respect to the construction of other railways connected with the main lines, so much so that in the history of nearly all the branch lines we find that after subscribing capital for the first estimated cost of a 3 ft. or 3 ft. 6 in. narrow-gauge

line, the next proceeding has been, in nearly all instances, to consider whether the gauge should not be changed to 4 ft. 8½ in.; and in most cases there has been an augmentation of capital to meet the difference in cost in maintaining the standard gauge. This was only a few weeks ago the case with the Malmö-Ystad line. In one instance, the Norberg line—constructed about ten years ago—a widening to the standard gauge is now going on to meet the approaching main line.[1]

However, there are instances where there is no more capital available, where railway communication is a necessity, and where the expected traffic is so small that it would hardly pay even for a narrow-gauge line. Of this class there are six lines, averaging 20 miles each in length, which may be termed feeders to the main line, cheaply constructed for low speed and light agricultural traffic. The comparison between the relative mileage of the broad and narrow gauge lines shows that the narrow-gauge idea has of late met with very little encouragement in Sweden.

In comparing the cost of the standard-gauge lines of heavy and light construction with the cost of the narrow-gauge lines, it is essential to include the speed as a most important factor, for unless that is done when comparing the cost of the standard gauge of heavy construction with that of the narrow gauge, the advantage is all on the side of the latter, but taking the speed in as a factor of the cost of making a line it seems to be more deserving of consideration than even the gauge.

The Swedish State lines, costing nearly £7,000 per mile, running at a maximum speed of 37 miles per hour, taken with the light lines of standard gauge at £4,000 a mile, with a speed of 23 miles per hour, give an average cost of standard-gauge lines amounting to about £6,000 per mile, capable of a general maximum speed of 33 miles.

Against this the narrow-gauge lines of different widths constructed at an average cost of £2,900 a mile, are capable of a maximum speed of, say, 15 miles per hour; but the reason why they are so much cheaper is that many of them are not adapted to passenger, but only for mineral and timber traffic. Finally, the two are set side by side in the table, so as to compare cost, speed, and gauge. It will be seen at once that the cost is nearly in direct proportion of the speed whatever may be the gauge, and of those comparing most favourably are the light standard gauge and the 3 ft. 6 in. gauge, which have an advance 4 per cent. of speed over that of cost, whereas the 4 ft. gauge has just so much less speed as compared with its cost. Singularly enough, besides the 628 miles of heavy lines of standard gauge now in construction, the two kinds of railways most in vogue in Sweden at the present time are the 400 miles of the light standard gauge, and the 88 miles of 3 ft. 6 in., but none of 4 ft.

In conclusion, as far as the practice on the Swedish railways goes, it must be first stated that the information given in the tables is put down as nearly as can be ascertained, and as fairly as possible. It is manifest that the figures are liable to modification, especially with regard to lines in construction, but they are given as estimated and in accordance with practice already obtained, and for the sole purpose of technical comparison. These results depending in great measure on local circumstances in Sweden may not be applicable to other countries except on similar conditions. There is of course nothing to prevent a higher speed

[1] Since the above was written the Swedish mail brings news of a contemplated widening of the 3 ft. 6 in.-gauge Sundsvall-Torpshammar line, in view of the approaching extension of State lines in that direction. This line, after careful consideration in Parliament, is to be constructed as a 'light railway' on the 4 ft. 8½ in. gauge.

being adopted on narrow-gauge railways than what is run on those in Sweden, but in such case they must be constructed for the purpose, with more favourable gradients and curves, with stronger permanent way and rolling stock, and at a consequently increased cost. So much so, that the conclusion Mr. Elworth, the Director of the State lines in Sweden, arrived at three years ago. as to the difference in cost between narrow gauge and broad gauge for the same kind of work done, seems to guide railway construction in Sweden even now, at least judging from the tables.

The cost of translading of goods and passengers, and the delay and inconvenience caused thereby, is unimportant when compared to the loss of time incurred by traveling over long distances at a low speed, but it should not be lost sight of where time is of value. In Sweden, with the standard gauge already established to a great extent, a cheaper and lighter construction seems to be preferred to break of gauge. This is at least the case with some of the private companies who cannot afford to copy the heavy system of broad gauge, of which the Government railways are the type.

As there are a great many opponents to the construction of light standard-gauge lines, worked in connection with the heavy ones, owing to the apprehended destruction of the lighter rails in case the engines in use on the heavily-constructed lines should run over them, the following calculations may possibly serve to obviate some of their objections :—

In the instance of the Swedish State lines, with rails weighing 66 lb. per yard, and a 27-ton engine running at 37 miles per hour, the maximum effect on the rail may be taken as $37 \times 27 = 999$.

In the case of a line of standard gauge of light construction with rails weighing 50 lb. per yard, as used on some of the joining lines, we have $66 : 50 :: 999 : 756$ and $\frac{756}{27} = 28$ miles per hour, as the proportionate maximum speed for the lighter rail, so far as safety is concerned. As, however, there are also other effects of the heavy engine, such as crushing the rail-head, and bending the rail, the load on each driver must in no case exceed one-half and two-thirds of what the rail and rail joint will carry without taking a permanent set. It is clear that the reduction of the speed cannot compensate for too great a disproportion in the weight of the engine as compared with that of the permanent way; but on the other hand it is obvious that where the difference is not too great, the lowering of the speed will overcome the difficulty of absolutely limiting the rolling stock to its respective road. In case of emergency, such as war, a somewhat heavier rolling stock could very well be used without risk, although it is quite right that each road should, as far as possible, be worked by rolling stock suited to it. In giving these weights of rails, it need scarcely be said that their efficiency does not depend solely upon the weight, but also upon the form of section and the quality, inasmuch as a 50 lb. rail of modern section and good quality will do the work of a 66 lb. section if of extravagant form and poor quality. Although Sweden can show a few cheap narrow-gauge lines, the light construction of the broad gauge is preferred from sufficiently long experience of their relative value. The reason seems to lie in the warning presented by the solitary example of break of gauge, coupled with the already firm establishment of the standard gauge in the country, and not from any disbelief in the efficiency of the narrow gauge, judged by itself, for countries where there is no standard gauge system already constructed.

TABLE I.—COST, GAUGE, AND SPEED

Name of Line.	Mileage.	Weight of Rail, lbs. per Yard.	Total Cost of Construction per English Mile. (Single Line) 4 ft. 8½ in. Gauge.	4 ft. 8½ in. Gauge.	4 ft. 0 in. Gauge.	3 ft. 6 in. Gauge.	2 ft. 6 in. Gauge.
		lbs.	£	£	£	£	£
State Lines	692	66	7,450	Standard Gauge, Heavy Construction.			
Royal Swedish . . .	54	66	6,311				
Gefle-Dala	57	60	6,817				
Total	803	Miles at £7,328.					
Ystad-Eslof	47	50	..	4,477	Standard Gauge, Light Construction.		
Landscrona - Helsingborg-Eslof . . .	37	50	..	4,778			
Kristianstad - Hessleholm	18	50	..	4,739			
Wexiö-Alfvesta . . .	11	50	..	3,784			
Marma Sandarde . .	6	44	..	5,584			
Total	119	Miles at	..	£4,603			
Boras-Herrljunga . .	25	46	Connected with Standard Gauge Lines.		4,517	Narrow Gauge.	
Uddevalla - Wenersborg-Herrljunga . . .	57	43			4,675		
Wessman Barken . .	11	40			4,094		
Norberg	10	44			3,517		
Söderhamn	9	40			5,030		
Hudiksvall	7	45			3,800		
Total	119	Miles	at ..	.. £	4,466		
Köping-Uttersberg . .	22	34	Unconnected Lines.		..	1,960	..
Kristinehamn-Sjöändan	7	25			..	3,428	..
Fryksta	4	25			..	2,370	..
Total	33	Miles	at ..	..	.. £	2,322	
Kroppa	6	18	Miles at	..	..	.. £	1,440

OF LINES OPEN FOR TRAFFIC IN SWEDEN.

Working Results for 1871.			Working Conditions.			
Gross Receipts per Mile.	Proportion of Working Expenses to gross Receipts.	Net Profit on Cost of Construction.	Open for Traffic. Years.	Speed Worked to. Maximum.	Speed Worked to. Average.	Description of Traffic.
£	per cent.	per cent.	medium.	miles per hour.		
616	50·2	3·7	10	39	26	Mixed.
508	56·8	3·4	17	24	16	Mineral.
1,449	42·3	12·1	14	22	15	Timber.
			Speed	37	25	
310	50·0	3·1	7	22	15	Agricultural.
498	50·1	5·1	8	24	16	,,
414	44·8	4·8	8	18	12	,,
381	54·9	4·2	8	24	16	,,
1,222	38·2	12·8	10	18	12	,,
			Speed	23	16	
327	41·4	4·2	10	26	17	,,
338	50·2	3·5	8	24	16	,,
424	50·4	5·0	13	15	10	Mineral.
477	40·1	8·0	17	21	14	,,
1,014	58·7	8·8	12	15	10	Timber.
650	48·3	8·7	13	15	10	,,
			Speed	22	14	
216	56·4	4·7	7	17	11	Mineral.
546	42·5	8·7	17	12	8	,,
509	35·0	13·8	22	12	8	,,
			Speed	15	10	
427	24·5	22·2	19	8	5	Mineral.

TABLE II.—COST, GAUGE, AND SPEED PROPOSED FOR LINES IN CONSTRUCTION IN SWEDEN

NAME OF RAILWAY.	Mileage.	Weight of Rail. lbs. per Yard.	Total Cost per English Mile (Single Line). 4 ft. 8½ in. Gauge.	4 ft. 8½ in. Gauge.	3 ft. 6 in. Gauge.	3 ft. Gauge.	2 ft. 6 in. Gauge.	Description of expected Traffic.
		lbs.	£					
State Lines . . .	162	66	7,000	..	..	..	..	Mixed.
Bergslagernas (Fahlun Kihl) . . .	123	64	7,000	..	..	..	..	Mineral and timber.
Halmstad Jönköping	97	..	4,639	Standard gauge, heavy construction, suited to a maximum speed of 37 miles per hour.				Timber.
Halsberg - Motala-Mjölby . . .	58	57	..					Mineral and timber.
Frövi-Ludvika . .	58	60	..					,, ,,
Stockholm-Westeras	117	56	..	..	..	..	..	,, ,,
Krylbo-Norberg. .	11	57	4,886	Widened from 4 ft. to 4 ft. 8½ in.				,, ,,
Total	626							

Average cost of 393 miles £6,358 per mile.

NAME OF RAILWAY.	Mileage.	Weight of Rail. lbs. per Yard.	4 ft. 8½ in. Gauge.	4 ft. 8½ in. Gauge.	3 ft. 6 in. Gauge.	3 ft. Gauge.	2 ft. 6 in. Gauge.	Description of expected Traffic.
Nyköping-Mölnbo .	32	..	..	3,160	..	..	..	Timber.
Nassjö Oscarshamn.	90	45	..	..	..	..	..	,,
Carlscrona-Wexio .	69	50	..	4,048	Standard gauge, light construction, suited to a maximum speed of 23 miles per hour.			,,
Upsala-Gefle . .	68	45	..	..				,,
Helsingborg Hesslcholm	47	45	..	3,907				Coal.
Kalmar-Emmeboda.	35	45	..	3,800				Timber.
Nora-Carlskoga. .	34	45	..	..	..	..	..	Mineral and timber.
Nynäsbanan. . .	25	36	..	..	..	..	..	Mixed.
Total	400							

Average cost of 183 miles .. £3,809 per mile.

NAME OF RAILWAY.	Mileage.	Weight of Rail. lbs. per Yard.	4 ft. 8½ in. Gauge.	4 ft. 8½ in. Gauge.	3 ft. 6 in. Gauge.	3 ft. Gauge.	2 ft. 6 in. Gauge.	Description of expected Traffic.
Sundsvall - Torpshammar . . .	39	45	..	..	3,134	Speed, say 15 miles per hour.		Timber.
Carlshamn - Wieslanda	49	36	..	..	2,154			,,
Total	88	miles	at	..	£2,588 per mile.			
Palsboda-Finspong.	34	30	Narrow Gauge.	Speed, say 10 miles per hour.		2,287	..	Mineral and timber.
Ulricehamn - Wartofta	23	25				1,304	..	Agricultural.
Total	57	miles	at	..	..	£1,904 per mile.		
Wikern-Mockeln .	21	25	..	..	..	..	1,754	Mineral.
Hjo-Stenstorp . .	19	..	..	..	Speed, say, 8 miles per hour.		1,754	Agricultural.
Lidköping - Skara-Stenstorp . . .	30	..	..	..	..	..	1,759	,,
Total	70	miles	at	..	..	..	£1,756 per mile.	

TABLE III.—COST, GAUGE, AND SPEED COMPARED OF RAILWAYS IN SWEDEN.

Standard, 4 ft. 8½ in. Gauge.		Narrow Gauge.			
Heavy Construction. Maximum Speed worked to 37 Miles per Hour.	Light Construction. Maximum Speed worked to 23 Miles per Hour.	4 ft. Maximum Speed worked to 22 Miles per Hour.	3 ft. 6 in. Maximum Speed worked to 15 Miles per Hour.	3 ft. Maximum Speed to be worked to 10 Miles per Hour.	2 ft. 6 in. Maximum Speed worked to 8 Miles per Hour.
LINES OPEN.					
miles 803 at £7,328	miles 119 at £4,603	miles 119 at £4,466	miles 33 at £2,322	..	miles 6 at £1,440
LINES IN CONSTRUCTION.					
miles 626 at £6,358	miles 400 at £3,809	..	miles 88 at £2,588	miles 57 at £1,904	miles 70 at £1,756
TOTAL MILES AT MEDIUM COST.					
miles 1,429 at £6,903	miles 519 at £3,991	miles 119 at £4,466	miles 121 at £2,515	miles 57 at £1,904	miles 76 at £1,731
Standard Gauge.		Narrow Gauge.			
1,948 miles at £6,127 per mile.		373 miles at £2,884 per mile.			
Worked at speed of 33 miles per hour.		Worked at speed of 15 miles per hour.			
COST COMPARED WITH SPEED PER CENT.					
Cost, 100 per ct.	58 per cent.	64 per cent.	36 per cent.	27 per cent.	25 per cent.
Speed, 100 „	62 „	60 „	40 „	27 „	22 „

NOTE.—Cost, 100 per cent. = £6,903 per mile.

Speed, 100 per cent. = 37 miles per hour.

IV.—Additional Memoranda as to the Denver and Rio Grande railway, by Mr. George Allan, M. Inst. C.E.

The following particulars of the Denver and Rio Grande Road can be relied upon as correct:—

Its track bed is from 10 ft. to 12 ft. wide, and is laid with sleepers of Rocky Mountain pine 6 in. by 5 in., 6 ft. long, and 2 ft. apart centre to centre.

The rails are of the Vignoles section, 30 lbs. to the yard, fish jointed, and in 24 ft. lengths.

The road is as well ballasted as any first-class American road, as, for instance, the Pennsylvania Central.

The passenger engines have 40 inch drivers, 4 wheels coupled, and a pair of small leading wheels; cylinders 9 in. by 16 in., weight on drivers 20,000 lbs., and total weight 25,000 lbs.

The freight engines have 36 inch drivers, 6 wheels coupled, and a pair of small leading wheels; cylinders 11 in. by 16 in., weight on drivers 30,000 lbs.; total weight 35,000 lbs.

Both classes are of the Pennsylvania Central Company's pattern, and each has a 4 wheel tender, weighing without coal and water 6,000 lbs.

All the carriages, or cars as they are called, are built on the bogie system.

The day cars are fitted up with two seats on one side and one seat on the other side of a central passage, and some are arranged somewhat after the fashion of Pullman's celebrated dining-room cars, with seats for one passenger on each side of the passage, or for two passengers at each table. The dimensions of the passenger cars are as follows:—

Length of platform	40 ft.
Ditto of body	35 „
Width of body outside	7 „
Ditto inside	6½ „
Height inside to centre of dome	7½ „
Ditto above rail to floor beams	2¼ „
Ditto above rail to top of dome	10½ „
Ditto of centre of gravity above rail.	3 ft. 2 in.
Angle of stability	50½°

Each car seats 36 passengers and has two water-closets. The bogies have each 4 wheels of 24 in. diameter. The total weight of a car is 15,000 lbs.

The freight stock consists of:—

	Weight.	Capacity.
4 wheel platform trucks	4,000 lbs.	10,000 lbs.
4 wheel high-sided trucks.	3,500 „	10,500 „
4 wheel covered trucks.	4,500 „	9,500 „
Bogie platform trucks	6,250 „	20,000 „

The bogie covered wagons are of the following dimensions, &c.:—

Length over the frame	23 ft.	7 in.
Ditto of body	22	1
Width of body outside	6	2
Ditto of body inside	6	
Height of floor above rail	2	4
Height inside	6	
Diameter of bogie wheels	20 in.	

Angle of stability when empty	56°
Ditto when loaded with wheat	51°
Floor area	132 square ft.
Space in box	792 cubic ft.
Weight	8,800 lbs.
Capacity	17,600 lbs.

The cattle cars are mounted on 4 wheel bogie trucks, with bodies 24 ft. long, by 6 ft. wide inside, their weight is 8,000 lbs. They carry each 9 head of cattle, whilst the cars on the 4 ft. 8½ in. gauge are 28 ft. long, weigh 18,000 lbs. to 20,000 lbs., and carry 14 head of cattle; the saving being 397 lbs. of dead weight per head in favour of the narrow gauge.

V.—ADDITIONAL MEMORANDA as to the GOODS TRAFFIC conveyed over the BOMBAY, BARODA, and CENTRAL INDIA RAILWAY, during the years 1870 and 1871, &c., by Lieut.-Colonel J. PITT KENNEDY, M. Inst. C.E.

The following Table gives a classification of the goods traffic conveyed over the Bombay, Baroda and Central India railway, 312 miles in extent, during the years 1870 and 1871. Columns 1 and 2 show 43 varieties of goods conveyed. Columns 3 and 4 show the approximate specific gravity, per cubic foot, compared with the bulk per ton of each kind. These columns are offered as the only test by which the fitness of different railway gauges, or the proper distance between the rails of the wagon track for the conveyance of traffic, can possibly be established, in accordance with the relation existing between the bulk and weight of the prevalent classes of product to be conveyed. They show that the fitting gauge for the conveyance of light products must be wide, while that for conveying heavy minerals may be narrow, whilst the wide gauge suits both light and heavy goods or materials. They prove that the 5 ft. 6 in. gauge, established for India in 1851, was the most suitable that could have been selected; and that the 3 ft. 3 in. gauge, now sought to be established, would not merely introduce the inconvenience of a break of gauge, as in England, but, in addition, would inflict a serious wound on the commerce of India, by providing a wholly unsuitable means of transport for the products to be conveyed.

	Cubic feet.
The first seven kinds of products (1 to 7) comprise goods of the lightest specific gravities, ranging from 224 to 90 cubic ft. per ton, and make an aggregate of	8,232,802
The next fifteen kinds (8 to 22), ranging from 80 to 50 cubic ft. per ton, make an aggregate of	7,202,827
The next fourteen kinds (23 to 36), ranging from 45 to 25 cubic ft. per ton, make an aggregate of	1,994,291
The last seven kinds (37 to 43), ranging from 20 to 5 cubic ft. per ton, make an aggregate of	270,735
All the above forty-three kinds, composing the entire year's traffic, varying in their specific gravities from 10 lbs. to 443 lbs. per cubic foot of bulk, make a total of	17,700,655

The goods so classified are in every respect adapted for transport in the existing

wagons of the 5 ft. 6 in. gauge, whilst only the last seven heavy kinds, 37 to 43, or less than one sixty-fifth part in bulk of the products, would be suitable for a 3 ft. 3 in. gauge.

The table also shows that nine-tenths of the ordinary traffic of populous districts consist of commodities applicable to the food and clothing, &c., of man, requiring bulky space in the vehicles of transport, and this applies equally to populous districts where minerals are produced. The minerals can be conveniently carried on a medium wide gauge. The bulky goods cannot be economically conveyed on a narrow gauge, which must necessarily in that case consist of double lines; nor can passengers, oxen, horses, infantry, cavalry, field artillery, or siege artillery. These must all be furnished with a wide through gauge line, whether short special branches of narrow gauge be used for minerals or not, as in Wales, in order to reach the nearest station on the general traffic line of the country. It is a most costly error to lay down a narrow-gauge line merely to initiate the improvement of a waste district. The right course in that case is to construct, when necessary, a good smooth carriage road from the most convenient station of the nearest railway, and laid out upon the best levels that the country will admit, to secure the power of ultimately laying down rails to the proper national gauge, but placing upon the road, in the interim, Thomson's traction engine and trucks without rails. Such a road, furnished with its train complete, need not cost more than £500 to £1,000 per mile, exclusive of large bridges; and when the district is developed up to the requirement of a regular railway, the rails can be laid down, and the road traction engine, with its train, can be moved forward to some other district requiring its temporary services without any loss or waste whatsoever. Twelve miles of improvable waste district can thus be put under a process of rapid improvement for what each single mile would cost upon the narrow gauge system.

The plea of economy urged by those who advocate the narrow-gauge lines for general traffic is a misleading delusion. Their complication where there is the amount of traffic requiring a railway would make them more costly, even as single lines, than those constructed on the proper gauge. The table refers to a line on the 5 ft. 6 in. gauge, 312 miles in length, with a ruling gradient of one in five hundred. The last extension of this line, 80 miles in length, has just been completed under the chief Resident Engineer, Mr. Francis Mathew, M. Inst. C.E., within an expenditure of £5,500 per mile. Had Mr. Mathew's rate of cost been the rule, instead of the exception, in constructing Indian railways, their profits from the commencement would—calculated at the existing rates of freights and fares—have reached from 8 per cent. to 10 per cent. on the outlay, and in that case nothing would have been heard of the absurd proposal of a reduction of gauge. Hence the remedy, now called for, is an extension of Mr. Mathew's principle of economically constructing railways upon the standard East Indian gauge of 5 ft. 6 in. A reduction of that gauge, as now proposed must be much more costly, and would be utterly incapable of providing for the requirements of traffic when it reaches the inevitable development due to a sufficiently extended railway intercourse. This future increase may be estimated at least as amounting to thirty-fold the present agricultural production, with a consequent proportional increase of railway traffic.

On this line we have not had occasion to run more than three through trains daily each way; when the traffic requires four through trains each way it will be time to lay a second track; four through trains daily each way would necessitate sixteen crossings between the up and down trains. But sixteen crossings on a narrow gauge of 3 ft. 3 in. could only get through

one-fifth of our traffic. Hence, had we been condemned to the narrow gauge we must have laid down a double line before we ever opened for traffic. In fact, the great characteristic of single line working is, that the number of crossings between up and down trains increases as the square of the number of through trains daily each way : on, say a twelve-hours' journey, our present three trains would give nine such crossings—quite complication enough. Their equivalent on the narrow-gauge single line would require the square of fifteen, or 225 crossings in a day—an utter impossibility!

Every competent engineer who lays down a line of railway must feel responsible for securing that what he provides shall suffice, not for the mere wants of the present day, but for keeping pace with the largest development of traffic that shall ever take place, without undoing anything that has been done.

In this view the principal subjects for consideration in any estimate as to the future maximum amount of traffic for which he or his successors must provide transport, may be summarized as follows:—

First.—That only about one-fourth of the surface of India is yet cultivated, owing to the deficiency of roads for the conveyance of produce to market.

Second.—That ignorance of sound principles in agriculture now limits the acreable produce of the cultivated land to less than one-fourth of what it must hereafter be when the present wise intentions of Government regarding agricultural instruction shall have had time to operate.

Third.—That the intended increase of irrigation from reservoirs, dams, and canals, &c., must still further enormously increase the surplus agricultural produce, for which transport must be hereafter provided.

Fourth.—That mineral produce is likewise only awaiting something like human energy for its further development.

Fifth.—That the trunk lines of India are enormously in excess of length as compared with those of England; a fact which must proportionally increase the comparative goods-truck accommodation that will in future be required upon Indian trunk lines.

Sixth.—That the London and North Western Railway Company, on a much wider gauge than that here objected to, have already been obliged to *quadruple* their 4 ft. 8½ in. tracks over one-third of their main line between London and Lancashire.

These memoranda may be appropriately closed with the following extract from the Victorian Correspondent's letter, dated Melbourne, 14th August, which appeared in the 'Times' of Tuesday, October 1st, 1872:—"A remarkable change in the views of our Lower House has served to illustrate the use of the Upper, to which our self-styled Liberals object as a mischievous obstruction. In considering the extension of our railway system in November, 1871, the Assembly, yielding to a popular cry for cheap construction and to the recommendations of the press, determined, in opposition to the decidedly expressed opinion of Mr. Higinbotham, the engineer-in-chief, to make the new lines on a 3 ft. 6 in. gauge, instead of continuing the former of 5 ft. 3 in. The Council, after hearing the evidence of the engineer and others, refused to pass the Construction Bill without a clause requiring the assent of both Houses to any change from the old gauge. The Assembly disagreed with the amendment, and the matter remained in abeyance until this Session. In the interval, our Agent-General had collected the opinions of eminent engineers from different parts of the world, which supported Mr. Higinbotham's view. The matter has been again discussed, and the Assembly reversed its former judgment by a majority of 42 to 10 against the break of gauge. The new lines are now being constructed on the 5 ft. 3 in. gauge."

TABLE giving the CLASSIFICATION and SPECIFIC GRAVITY of GOODS conveyed over the BOMBAY, BARODA, and CENTRAL INDIA RAILWAY, in the Years 1871 and 1870.

No. of Kind.	Classification of Goods conveyed.	Specific Gravity of each kind of Goods.		Total Goods carried during Year 1871.		Specific Gravity of each class of Goods.		Total Goods carried during Year 1870.	
		Weight per cubic foot in lbs.	Cubic feet per ton in Bulk.	Tons.	Cubic Feet.	Weight per cubic foot in lbs.	Cubic feet per ton in Bulk.	Tons.	Cubic Feet.
1	Unpressed cotton	10	224	220	49,280			121	27,104
2	Furniture	11	200	2,185	437,000			1,924	384,800
3	Half-pressed cotton	12	186	31,009	5,767,674			30,526	5,677,278
4	Cotton seeds	12	186	3,932	731,352			7,155	1,330,830
5	Wool	16	140	984	137,760			786	110,040
6	Fruit and vegetables	22	100	5,526	552,600			6,876	687,900
7	Eggs	25	90	176	15,840			165	14,850
Class 1	Averages and totals	13	174	44,032	7,691,506	13	173	47,553	8,232,802
8	Grass	28	80	1,973	157,840			1,021	81,680
9	Sundries	28	80	5,496	439,680			6,027	482,160
10	Bagging	32	70	1,178	82,460			1,047	73,290
11	Commissariat stores	32	70	1,393	97,510			1,288	90,160
12	Full-pressed cotton	32	70	7,492	524,440			5,359	375,130
13	Flax and hemp	32	70	27	1,820			65	4,550
14	Groceries	37	60	3,167	190,020			2,541	152,460
15	Grains and seed	37	60	45,237	2,714,220			77,627	4,657,620
16	Twist	37	60	1,325	79,500			1,452	87,120
17	Sugar	40	56	9,510	532,560			8,687	486,472
18	Soap	40	56	520	29,120			629	25,160
19	Firewood	40	56	5,582	312,592			2,616	104,640
20	Salt	44	51	4,348	221,748			1,900	96,900
21	Lime	44	51	1,665	84,915			835	42,585
22	Dry fruits	45	50	7,664	383,200			8,858	442,900
Class 2	Averages and totals	37	60	96,577	5,851,625	37	60	119,952	7,202,827

23	Jagree (molasses)	50	45	17,286	777,870			12,865	578,925
24	Kupas (seed cotton)	50	45	205	9,225			1,404	63,180
25	Mowra (flowers which produce spirit)	50	45	11,925	516,625			11,402	513,090
26	Timber	50	45	6,122	275,490			6,425	289,125
27	Ghee (clarified butter) . . .	56	40	1,142	45,680			1,062	42,480
28	Oil	56	40	843	33,720			804	32,160
29	Piece goods	56	40	6,023	240,920			5,434	217,360
30	Rape	56	40	408	16,320			439	17,560
31	Beer and spirits.	62	36	1,045	37,620			526	18,936
32	Coal	80	28	1,146	32,088			1,734	48,552
33	Paper	80	28	504	14,112			550	15,400
34	Tobacco	80	28	4,724	132,272			4,601	128,828
35	Opium	86	26	631	16,406			520	13,520
36	Machinery	90	25	551	13,775			607	15,175
Class 3	Averages and totals	54	41	52,555	2,162,123	55	41	48,373	1,994,291
37	Cutlery	112	20	38	760			42	840
38	Potash	112	20	377	7,540			282	5,640
39	Sand	112	20	135	2,700			321	6,420
40	Colour	124	18	1,587	30,366			1,442	25,956
41	Bricks	132	17	676	11,492			2,257	38,369
42	Stone.	148	15	2,384	35,760			10,891	163,365
43	Metal	443	5	4,549	22,745			6,029	30,145
Class 4	Averages and totals	203	11	9,746	111,363	176	12	21,264	270,735
	Averages and totals	28	78	202,910	15,816,617	30	75	237,142	17,700,655

VI.—Report of Mr. J. E. TANNER, M. Inst. C.E., on a LIGHT RAILWAY to connect the LARGER TOWNS of the PUNJÂB with Lahore.

MY DEAR SAUNDERS, *December* 6, 1861.

I HEREWITH send you the estimate you asked me to make out. I have made it out for 50 (fifty) miles, as the rolling stock, &c., will be about the same for every 50 miles.

The expense of the construction of the proposed railway is not much when we consider that money is about to be expended on the conservancy of the Indus and Jailaw, and that money spent on such conservancy will be an annual expense to the Government of the Punjâb, for do what one may to procure a good channel, fit for the present or any kind of steam-boat (compatible with really quick traffic), the unstable soil of the bank with such a stream renders the said channel liable to be shifted in the course of a single night. All money expended on conservancy may be styled a venture; while such is not the case with money expended in converting one-half of the present roads into a light railway suitable for low speeds.

The annual expenditure of keeping up the Dâk horses and carts, bullock trains, &c., and the large staff of servants necessary for the present Dâk, would go towards the construction of the proposed light railway. The use of one-half of the roads has often been agreed in favour for a railway; and with the proposed speed an objection can hardly be raised, as 12 miles an hour is about the rate that the Dâk cart itself travels.

Yours sincerely,

(Signed) JOHN EDWARD TANNER.

R. SAUNDERS, Esq., Postmaster-General, Punjâb.

India is only ready for railways in the neighbourhood of such cities as Calcutta, Madras, Bombay, Kurrachee, Lahore, Umritsir, and Mooltan, where undoubtedly they will soon repay the money expended on them, to connect Kotree with Mooltan, Lahore with Peshawur, Lahore with Ferozepoor, Rawul-Pindee with Murree, Umballah with Kalka, and Meerut with Delhi; between which towns the traffic is very great, but not sufficient to induce the Government to grant the 5 per cent. guarantee on the enormous outlay necessary for a railway, for it could not pay as a matter of speculation for years to come. It behoves us, therefore, to procure a means of carrying goods and passengers with a certainty and speed much greater than can be attained by horses and camels. Surely this could be performed by a light railway, and the traffic carried by light engines on the longer lines, and by horses on the shorter branches. Speed with the light engines not to exceed 8 miles for goods and 12 miles for passengers. In this way the traffic would increase in the same proportion as if a railway (proper) had been constructed.

When the traffic requires greater speed, then a railway can be constructed with a certainty of paying; and the light rails that had been used could then be laid down between other towns that would be ready for such a branch line.

Rails.—The rails I would propose would be of the weight of 28 lbs. a yard run, which would suit a traffic of 8 miles for goods and 12 miles for passengers. Between Kotree and Mooltan I would propose a rather heavier rail—32 lbs. a yard—for that is the only link wanting of W. P. Andrew, Esq.'s scheme, and must, as he always foretold, make Kurrachee the best port for all passengers from India to England, and will bring even Calcutta a week nearer to England.

Sleepers.—The difficulty in procuring wood for sleepers in the Punjâb makes it

almost a necessity that Greave's cast-iron pots should be used. They are not difficult in packing while laying the line; and in moving the line at any time to another part of the country we should not be put to the expense of renewing worn-out sleepers, while the extra expense in the first instance is very slight.

Earthwork.—If one-half of the road is allowed to be used for the railway, the bridges and earthwork will be very slight.

Fencing.—Fencing to be made of balrol or other hard wood, except when water is easily procurable, and then a low mud wall.

Tank and Stations.—As there is a well close to the road at all the serrails, a small tank made of wood capable of containing water for 3 (three) engines, and a shed for receiving goods, is all that will be necessary; and the serrails and Dâk bungalows will answer amply for station accommodation for the present. When the traffic requires more, such a station as is suited to the requirements can easily be built.

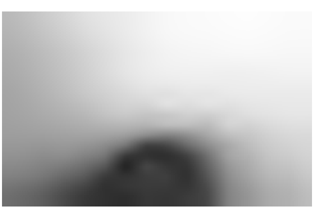
Engines and Rolling Stock.—The engines would cost in England about £800 to £1,000. The trucks must differ according to the kinds of traffic expected.

Laying the Line.—The rails from their lightness will be easy to handle, which will overcome the great difficulty we have in India of laying heavy rails. The rails might be laid at the rate of six miles a month, with two English platelayers for superintending the gangs. As camels could carry the rails easily, there would be no great difficulty in getting the rails from the river bank, or carrying our own material.

Expense for the construction of 50 miles of proposed light railway	£100,000
Per mile (exclusive of rolling stock)	2,000

Crossing the Rivers.—The best way for crossing the rivers would be by a steam ferry. A pier would have to be run out on each side of the river; and as there will be no heavy superstructure, and the trains themselves will be light, they need not be expensive, but only sufficiently strong to prevent their being washed away by the floods.

(Signed) JOHN EDWARD TANNER, M. Inst. C.E.



INDEX.

Airy, Sir G. B., remarks as to the Royal Commission appointed, in 1845, to consider the question of the break of gauge, 69.—Ditto as to the introduction of a break of gauge in India, 70, 72.—Ditto as to numerical estimates of the inconveniences of break of gauge, 71.—Ditto as to a change of gauge and rolling-stock on the Eastern Counties railway, 71.—Ditto as to the impossibility of providing rolling-stock upon one railway, so as to be always ready to meet that upon another gauge, 71.—Ditto as to the extreme character of the difficulty of break of gauge in India, owing to that country being held by the sword, 71.—Ditto as to the question of width of gauge as applied to India, 72.—Ditto as to the difficulty of carrying field artillery and horses on narrow-gauge lines, 72.—Ditto as to the curves on the Todmorden Valley railway, 72.—Ditto as to the importance of rails not being over-canted, and as to conical tires, 72.

Allan, G., remarks as to the actual construction and working of narrow-gauge railways in the United States, and particularly of the Denver and Rio Grande, 3 ft. gauge, railway, 164.—Ditto as to the conclusions arrived at by the American convention of railway engineers, held at St. Louis in 1872, 165.—Ditto as to the capacity of narrow-gauge wagons for the conveyance of live stock, &c., 166.—Ditto as to the dividend paid by the Denver and Rio Grande railway, 167.—Ditto as to the sufficiency of the mètre gauge for the amount of traffic carried on the Indian railways, 167.—Ditto as to the questions of speed, of break of gauge, and of the fitness of the mètre-gauge railways for military purposes, 167, 168.—Ditto as to the effect of a break of gauge at Lahore, 168.—Additional memoranda as to the Denver and Rio Grande railway, 317.

Allport, J., remarks as to the evils of break of gauge, 101, 103.—Ditto as to the expense and loss arising from the transhipment of salt from the narrow gauge to the broad gauge at Bristol, 101.—Ditto as to the extra weight of the broad-gauge trucks causing loss as dead weight in the transhipment of general goods traffic, 102.—Ditto as to the difficulties attendant upon the transhipment of the men, horses, and guns of an army, 102.—Ditto as to the difficulties of the break of gauge on the Grand Trunk railway of Canada, 103.—Ditto as to its being possible that the adoption of the narrow gauge for the State railways of India might entail the loss of that country to the governing classes, 103.—Ditto as to its being imperative that the entire railway system of India should be constructed upon one uniform gauge, 103.

Appendix to discussion, 257.—I. "East India (Railways): Return to an address of the Honourable the House of Commons, dated 11th March, 1873;—for 'Copies of Correspondence between the Government of India and Court of Directors, relating to the present gauge of 5 ft. 6 in. of the Indian railways; and of the minutes of Lord Dalhousie and the reports of the consulting engineers on the subject of the gauge,'" 258.—II. Report of Mr. C. B. Vignoles,

INDEX.

Airy, Sir G. B., remarks as to the Royal Commission appointed, in 1845, to consider the question of the break of gauge, 69.—Ditto as to the introduction of a break of gauge in India, 70, 72.—Ditto as to numerical estimates of the inconveniences of break of gauge, 71.—Ditto as to a change of gauge and rolling-stock on the Eastern Counties railway, 71.—Ditto as to the impossibility of providing rolling-stock upon one railway, so as to be always ready to meet that upon another gauge, 71.—Ditto as to the extreme character of the difficulty of break of gauge in India, owing to that country being held by the sword, 71.—Ditto as to the question of width of gauge as applied to India, 72.—Ditto as to the difficulty of carrying field artillery and horses on narrow-gauge lines, 72.—Ditto as to the curves on the Todmorden Valley railway, 72.—Ditto as to the importance of rails not being over-canted, and as to conical tires, 72.

Allan, G., remarks as to the actual construction and working of narrow-gauge railways in the United States, and particularly of the Denver and Rio Grande, 3 ft. gauge, railway, 164. — Ditto as to the conclusions arrived at by the American convention of railway engineers, held at St. Louis in 1872, 165.—Ditto as to the capacity of narrow-gauge wagons for the conveyance of live stock, &c., 166.—Ditto as to the dividend paid by the Denver and Rio Grande railway, 167.—Ditto as to the sufficiency of the mètre gauge for the amount of traffic carried on the Indian railways, 167.—Ditto as to the questions of speed, of break of gauge, and of the fitness of the mètre-gauge railways for military purposes, 167, 168.—Ditto as to the effect of a break of gauge at Lahore, 168.—Additional memoranda as to the Denver and Rio Grande railway, 317.

Allport, J., remarks as to the evils of break of gauge, 101, 103.—Ditto as to the expense and loss arising from the transhipment of salt from the narrow gauge to the broad gauge at Bristol, 101.—Ditto as to the extra weight of the broad-gauge trucks causing loss as dead weight in the transhipment of general goods traffic, 102.—Ditto as to the difficulties attendant upon the transhipment of the men, horses, and guns of an army, 102.—Ditto as to the difficulties of the break of gauge on the Grand Trunk railway of Canada, 103.—Ditto as to its being possible that the adoption of the narrow gauge for the State railways of India might entail the loss of that country to the governing classes, 103.—Ditto as to its being imperative that the entire railway system of India should be constructed upon one uniform gauge, 103.

Appendix to discussion, 257.—I. "East India (Railways): Return to an address of the Honourable the House of Commons, dated 11th March, 1873;—for 'Copies of Correspondence between the Government of India and Court of Directors, relating to the present gauge of 5 ft. 6 in. of the Indian railways; and of the minutes of Lord Dalhousie and the reports of the consulting engineers on the subject of the gauge,'" 258.—II. Report of Mr. C. B. Vignoles,

F.R.S., Past President Inst. C.E., on the Hindostanee railway, September 22, 1842, 264.—III. Additional memoranda as to the Swedish railway system, by Mr. C. P. Sandberg, Assoc. Inst. C.E., 309.—IV. Additional memoranda as to the Denver and Rio Grande railway, by Mr. George Allan, M. Inst. C.E., 317. —V. Additional memoranda as to the goods traffic conveyed over the Bombay, Baroda, and Central India railway, during the years 1870 and 1871, &c., by Lieut.-Colonel J. Pitt Kennedy, M. Inst. C.E., 318.—VI. Report of Mr. J. E. Tanner, M. Inst. C.E., on a Light Railway to connect the larger towns of the Punjâb with Lahore, December 6, 1861, 323.

Andrew, W. P., remarks as to cheap railways, and a break of gauge being two distinct questions, 18.—Ditto as to the Indus Valley line of railway having been so long delayed, 18.—Ditto as to the introduction of a break of gauge into the Indian territory, 18.—Ditto as to the evils, confusion, and loss, incident to a break of gauge on the Great Western railway, 19.—Ditto as to the difficulty and confusion involved in the movement of troops, especially in India, 19.—Ditto as to the Umbeyla campaign, 19.—Ditto as to the political importance of the question of the Indus Valley system of railways with branches to the Khyber and Bolan passes, 20.—Ditto as to the benefits which the taxpayer of India derived from the payment necessary to make up the guaranteed interest on railways, 21. —Ditto as to the extent of increase of the commerce of India after the introduction of railways, with tables of the trade, revenue, and debt, in illustration, 21, 22.—Ditto as to the traffic on the Punjâb railway, and as to the population and area of the Punjâb, 22, 23.—Ditto as to the charge for the transhipment of goods from one gauge to another, 23.—Ditto as to the question of railways in India not yielding a direct profit, and as to the counterbalancing political and military advantages, 23.—Ditto as to the provision of £1,600,000 for the deficit occurring from the railways now in operation, 160.—Ditto as to the railways in India not paying large dividends being the fault of the Government, in not having paid sufficient attention to the construction of common roads, 160.—Ditto as to the sites of railway bridges in the Punjâb, 160.—Ditto as to the Scinde railway now being meant to compete with the river Indus, 161.—Ditto as to the break of gauge in the Indus Valley being a matter of Imperial importance, 161.

Berkley, G., remarks as to the introduction of the narrow gauge, and of breaks of gauge, 174.—Ditto as to the fallacy of comparing the cost of existing railways with estimates for narrow-gauge railways of inferior capacity, 175.—Ditto as to the necessity for considering the increase of wealth and of commercial activity caused by the introduction of railways into a country, 176, 177. —Ditto as to the assumption that heavy rails would be adopted if the State railways of India were made on the 5 ft. 6 in. gauge, 176.—Ditto as to the use of heavy engines on light rails at a low speed, 176.—Ditto as to the length of State railways under construction, or now intended to be made, 177.—Ditto as to the want of bad weather roads in India, 177.—Ditto as to the construction of railways being justified by advantages not represented by dividend, 177.—Ditto as to the effect of the introduction of railways into India, and as to the increase in the imports and exports since the year 1849, 178, 179.—Ditto as to the saving effected by the railways in the carriage of cotton, 178.—Ditto as to the dividend now earned not representing the required capacity of the existing railways, 178.—Ditto as to the necessity for making railways capable of carrying at least the maximum existing traffic, 179.—Ditto as to the traffic

on a part of the Great Indian Peninsula railway, 179.—Ditto as to the traffic on English railways between the years 1849 and 1867, 179.—Ditto as to a misapprehension which he thought had arisen with regard to Mr. Fowler's report, 179.—Ditto as to Mr. Bruce's estimates of the cost of lines made in India on the 5 ft. 6 in. gauge and on the mètre gauge, 180.—Ditto as to the average excess of cost of the railways on the 5 ft. 6 in. gauge, 181.—Ditto as to the saving to be effected by making railways on the mètre gauge not being equivalent to the serious disadvantages of breaks of gauge, 181.—Ditto as to the Indore line, and as to the evils of breaks of gauge to be established on that line by the construction of the proposed State railways passing Indore, 181.—Ditto as to the questions of cost of maintenance and of working, 184.—Ditto as to the evils of a break of gauge in India, 182.—Ditto as to the alteration of the gauge on the Great Western railway, 182.—Ditto as to the desirability of proceeding with works which would increase the productiveness of India, and utilise the existing railways, 183.

Bidder, G. P., Past-President, remarks as to a report made by him to the directors of the Scinde, Punjàb, and Delhi railways, as to the probable consequences of the introduction of the 3 ft. 6 in. gauge into India, 35.—Ditto as to a Commission being appointed to proceed to Norway to inspect a railway in that country, 35.—Ditto as to a railway in Norway on a 3 ft. 6 in. gauge between Christiania and the Port of Drammen, 36.—Ditto as to the Norwegian 'Storthing,' or Parliament, having enacted that for the future the State railways should only be constructed on the standard gauge of 4 ft. 8½ in., 36.—Ditto as to the large dividend on the Festiniog railway arising entirely from the exceptional character of the traffic, 36.—Ditto as to the alleged economy in the introduction of the mètre gauge for the Indus Valley railway, 36, 37.—Ditto as to the cost of transport in India, and as to the charge made by the East Indian railway for hauling up engines and wagons from Calcutta to Delhi, 37.—Ditto as to the rolling-stock required for a railway broken up into sections, 37.—Ditto as to the traffic of the Indus Valley, 37.—Ditto as to the saving effected in rolling-stock from the adoption of a continuous line of railway, 38.—Ditto as to an estimate of the several items and total extra cost involved in adopting the mètre gauge for the State railways of India, 38.—Ditto as to the inconveniences resulting from ditto, ditto, 38.—Ditto as to the commercial loss per ton resulting from a break of gauge, and as to the change of gauge on the Great Western railway, 38, 39.—Ditto as to the advantages derived by the people of India from the construction of railways, 39.—Ditto as to the original financial arrangement for executing the Indian State railways, and as to the desirability of its being altered, 39.—Ditto as to a contract for the construction of the Delhi railway, 40.—Ditto as to the mode in which technical investigations were conducted on behalf of the Indian Government, 40, 41.—Ditto as to a report upon the economy which could be effected in the Indus flotilla, 41.—Ditto as to the difficulties arising from want of practical knowledge on the part of the military officers employed by the Indian Government upon public works, 41.—Ditto as to the reason for the adoption of the mètre gauge for the State railways of India, 41.—Ditto as to the width of the rolling-stock proposed for ditto, and as to the consequent width of the formation of the excavations, over-bridges, and under-bridges, 42.—Ditto as to an extract from a report of Mr. Juland Danvers, made in 1872, 42.—Ditto as to the desirability that the development of the Indian railways should not be arrested by the introduction of a break of gauge, 42.—Ditto as to an extract from a minute of

the late Earl of Dalhousie, Governor-General of India, respecting the gauge of Indian railways, dated 4th July, 1850, 43.

Bruce, G. B., remarks as to whether the saving to be effected by the introduction of a new gauge into the Indian railway system would compensate for the evils of a break of gauge, 55, 56.—Ditto as to working the traffic of broad-gauge railways with light rails by light engines and rolling-stock, 55.—Ditto as to the money value of a break of gauge, 56.—Ditto as to the alleged saving of constructing the Indian State railways on the narrow gauge, which had been deduced from the estimates of Mr. Hawkshaw and of Mr. Fowler, 56, 58, 60, 231. —Ditto as to the estimates for 216 miles of mètre-gauge railway constructing in the south of India, 57.—Ditto as to the width of the vehicles being a truer test of the cost of a railway than the width of the gauge, 58.—Ditto as to the alleged economy in working narrow-gauge lines, 59.—Ditto as to the Indian guaranteed railways not paying, 59.—Ditto as to running heavy engines over light rails, 60.—Ditto as to the platforms on the Madras railway, 60.

Brunlees, J., remarks as to the gauge of railways being a question of circumstances, 122.—Ditto as to the Brazilian railway system, 123.—Ditto as to the comparative area and population of India and of Brazil, 123.—Ditto as to both broad-gauge railways and narrow-gauge railways being required in India, 123. —Ditto as to the objections to the use of the 5 ft. 6 in. gauge for the railways of India, 124.—Ditto as to avoiding a break of gauge on the main trunk lines by a more economical construction of lines on the 5 ft. 6 in. gauge, 124.—Ditto as to the construction of mètre-gauge lines of the character of steam tramroads as feeders to the railway system, 124.—Ditto as to its being an error to construct the Indus Valley railway as a narrow-gauge line, 125.—Ditto as to the inconvenience and delay occasioned by the Mont Cenis summit line constructed upon a narrow gauge between the French system of railways at St. Michel and the Italian system at Susa, 125, 126.—Ditto as to a break of gauge being an evil to be avoided at almost any cost of construction, 126.

Danvers, J., remarks as to the cost of railways being in proportion to their dimensions, 116.—Ditto as to the cost of the Oudh and Rohilkund railway, severally estimated as a broad-gauge line, and as a narrow-gauge line, 116.—Ditto as to several estimates of the relative cost of narrow-gauge railways and of broad-gauge railways, 117.—Ditto as to light narrow-gauge lines being sufficient to accommodate most districts in India, 117.—Ditto as to break of gauge, 117.

Dennis, W., remarks as to the saving which would have resulted from the construction of a line in the west of England on the 4 ft. 8½ in. gauge, instead of on the 7 ft. gauge, 191.—Ditto as to a tabular statement giving the comparative cost of construction of the line on both gauges, 192, 193.—Ditto as to the railway being one of only average difficulty, 192.

Evans, W. W., reference to his report against the use of the narrow gauge for the railways of the British Colony of Victoria, 122.

Fox, C. D., remarks as to the cost of constructing and of working railways not being entirely dependent upon the gauge, 62.—Ditto as to the necessity, in adopting a gauge, of considering the special circumstances and requirements of the country, 62, 63.—Ditto as to the gauges adopted in India, Canada, Ireland, Queensland, and Norway, 62, 63.—Ditto as to the efficiency of the 3 ft. 6 in. gauge, 63, 65.—Ditto as to break of gauge and interchange of rolling-stock, 64. —Ditto as to alterations of gauge in England, Canada, and the United States,

64.—Ditto as to the capacity of the 3 ft. 6 in. gauge, and as to the width and dimensions of the rolling stock adopted in Queensland, in Canada, and in India, 65, 66.—Ditto as to the cost of running trains or of hauling goods on different gauges, 66.—Ditto as to the comparative cost of broad-gauge railways and of narrow-gauge railways, 66.—Ditto as to a contract between the Carnatic Railway Company and the Secretary of State for India, entered into in 1870, and as to the construction of light broad-gauge lines in England and in India, 67, 68.—Ditto as to the existing and proposed railway system of India, 68, 69.

Galton, D., Captain, R.E., remarks as to the undesirability of introducing the mètre gauge into the Indian railway system, 73.—Ditto as to the question of sidings, 73.—Ditto as to break of gauge and as to the cost of transhipment of goods, 74.—Ditto as to the amount of damage to salt from transhipment, 74.—Ditto as to the effect of railways upon the movements of an army, 75. —Ditto as to the arrangements made by the Germans during the Franco-Prussian war for the supplies of their army in France, 75.—Ditto ditto for the conveyance of the wounded, 75.—Ditto as to the alleged difficulty of controlling the expenditure on Indian railways, 76.—Ditto as to the construction of railways under Government instead of under companies, 76.

Grierson, J., remarks as to the respective lengths of broad gauge, of mixed gauge, and of narrow gauge, on the Great Western railway, 206.—Ditto as to the rolling-stock and engines on ditto, 206.—Ditto as to the breaks of gauge on ditto, and as to the amount of tonnage transferred in the course of a year in consequence, 206.—Ditto as to the objections to break of gauge, 206.—Ditto as to the cost of transfer, 206.—Ditto as to damage to goods from a transfer, 207.—Ditto as to the amount of compensation for damage to goods arising from transfer, incurred by the Great Western Railway Company, during the year 1870, 207.—Ditto as to the delay arising from break of gauge, 208.—Ditto as to the construction of new lines of railway on a different gauge from that of existing lines being in some cases a desirable course to adopt, 208.—Ditto as to a railway on a 3 ft. 6 in. gauge, which was being constructed from the railways on the 5 ft. 3 in. gauge from Ennis to the coast of Clare, 208.—Ditto as to the alteration in the gauge of the Great Western railway, 208.—Ditto as to the broad gauge on that line, 209.—Ditto as to the necessity of adopting an uniform gauge throughout South Wales, 209.—Ditto as to an extract from a memorial from manufacturers, merchants, colliery owners, and others, in 1866, for the extension of the narrow gauge throughout the South Wales line, 210.—Ditto as to the alteration of 273 miles of railway west of Swindon, 210.—Ditto as to the advantages derived from the existence of an uniform gauge throughout that district, 211.—Ditto as to a letter from Mr. A. Brogden as to the beneficial effect of ditto, 211.—Ditto as to the separation of the railway systems of India by the adoption of the mètre gauge for the proposed lines, 211.—Ditto as to the change of gauge on the West Cornwall railway from Truro to Penzance, 211.—Ditto as to the dividend earned by the existing railways in India, 212.—Ditto as to the value of railways to a country, 212. —Ditto as to the strategic evils of a break of gauge, 213, 214.—Ditto as to the movement of troops in the United Kingdom, and as to the delay arising from the required concentration of the rolling-stock, 213.—Ditto as to the provision of rolling-stock on the Lahore-Peshawur line, 213.—Ditto as to the destruction of the rolling-stock of that narrow-gauge line being equivalent to the destruction of the railway itself for all practical purposes, 214.—Ditto as to the advantages

of constructing that line on the 5 ft. 6 in. gauge, 214.—Ditto as to a report of the Royal Commission on Railways in 1867, 214.—Ditto as to the probable necessity of the future alteration of one of the gauges on trunk lines, if the proposed new lines in India were made on the mètre gauge, 214.—Ditto as to the choice of mètre-gauge railways or of no railways in India, 215.—Ditto as to the desirability of avoiding break of gauge on trunk lines, 215.—Ditto as to the necessity for a continuous gauge between Calcutta, Kotree, and Peshawur, 215.

Grover, J. W., remarks as to altering the gauge of the existing lines, 184, 185.—Ditto as to the saving of a mètre-gauge line over one of 4 ft. 8½ in. gauge, 184.—Ditto as to the width of vehicles compared with the width of gauge, 185.—Ditto as to the cost of altering the gauge of existing lines, 185, 186.—Ditto as to the change of rolling-stock and of engines, 186.

Harrison, T. E., Vice-President, remarks as to the traffic on the original Newcastle and Carlisle railway being worked by light engines, light carriages, and light wagons, 24.—Ditto as to the cars in use on the narrow-gauge lines, 24.—Ditto as to the estimates of Mr. Hawkshaw and of Mr. Fowler, 24.—Ditto as to the particular items of ditto, 24, 25, 26, 27.—Ditto as to the alleged saving on a narrow-gauge line by adopting sharp curves, 27, 28.—Ditto as to the saving in construction of a mètre-gauge line as compared with a light broad-gauge line, 28.—Ditto as to other circumstances, besides the question of permanent way, entering into the construction of cheap lines, 28.—Ditto as to the construction of the Selby and York railway, and as to a permanent way laid down by the contractor for his own purposes, 28.—Ditto as to the introduction of the mètre gauge, of the mixed gauge, and of a break of gauge into the Punjâb system of railways, 29.—Ditto as to the change of gauge in the South Wales district, 29.—Ditto as to the estimated saving as between the mètre gauge and the Indian standard gauge, 29.—Ditto as to the impossibility of working two systems of gauge with the same amount of stock required for an uniform gauge, 30.—Ditto as to the additional cost in maintaining a mixed gauge, 30.—Ditto as to the saving effected by taking up the mixed gauge on the Oxford line of the Great Western railway, 30.—Ditto as to the proposed introduction of the mètre gauge on the Punjâb system of railways being the occasioning of an increased cost to the Indian Government, 31.—Ditto as to the actual cost of working the mètre gauge, 31.—Ditto as to the expense of working and maintenance of the Festiniog railway, and as to the relative cost of working lines of different gauges, 31.

Hawkshaw, J., Past-President, remarks as to a report made by him for the Eastern Bengal Railway Company, in reference to whether that railway should be extended on the narrow gauge instead of on the existing gauge, 32, 33.—Ditto as to a report by Mr. Fowler, 32.—Ditto as to the average saving which would result from constructing the State railways of India on the mètre gauge, 32, 33.—Ditto as to the evils and cost of a break of gauge, 33.—Ditto as to the dividends paid by railways to their proprietors, not being an accurate measure of the national advantages afforded by their construction and maintenance, 34.—Ditto as to the questions of the gauge, and of the character of a railway, in a strategic point of view, 34.—Ditto as to the importance of forwarding troops in India with the least possible obstruction, 34.—Ditto as to the crudity of the scheme propounded by the Government for the State railways of India, 35.

Hawksley, T., President, remarks as to its being more necessary to view the subject under the strategic than under the economical aspect, 254.—Ditto as to the possibility of an enemy invading India at the frontier contemporaneously with a mutiny or an insurrection, 255.—Ditto as to the adoption of a gauge narrower than the 5 ft. 6 in. gauge in the parts of India naturally protected from invasion, and where the population was sparse, 255.—Ditto as to the relative population of England and of India, 255.—Ditto as to the insufficiency of the mètre gauge for the main lines of India, 255.—Ditto as to the inexpediency of introducing another gauge into the main line extension of the railways of India, 256.—Ditto as to a recently acquired irregular habit of reading speeches in the course of the discussions, which the Council hoped would be abandoned, 256.

Heppel, G. G., remarks as to the failure of a light rail tried on the Oudh and Rohilkund railway, 205.—Ditto as to the weight and section of the rail, 205.—Ditto as to the cause of its failure, 205.—Ditto as to the failure not being a conclusive proof that light broad-gauge lines could not be satisfactorily constructed and maintained, 205.—Ditto as to the adoption of light broad-gauge lines being the only practical way of obtaining economy in the working and maintaining of new railways, 206.—Ditto as to the weight of rail to be used on ditto, 206.

Kennedy, Lieut.-Colonel J. P., remarks as to the evil effects of a break of gauge, 183. —Ditto as to a mètre gauge being inapplicable to the peculiar traffic of India, 183.—Ditto as to making the width of the wagon-load proportionate to the width of the gauge, 183.—Ditto as to the goods traffic conveyed over the Bombay, Baroda, and Central India railway, 184.—Ditto as to a classification of the goods traffic being the only test by which the fitness of different railway gauges could be established, 184.—Additional memoranda as to the goods traffic conveyed over the Bombay, Baroda, and Central India railway during the years 1870 and 1871, &c., 318.

Lawrence, Lord, remarks as to the gauge of the State railways of India being a question of cost rather than one of convenience, 112, 113.—Ditto as to the estimated cost of railways on the narrow gauge and on the 5 ft. 6 in. gauge, 112.—Ditto as to the line from Peshawur to Lahore, and from Lahore to Kurrachee, and as to break of gauge, 113.—Ditto as to the movement of troops, and as to railways on the mètre gauge being sufficient for all the requirements of the frontier, 114.—Ditto as to the question of a break of gauge in India being one as much for the financier, administrator, and statesman as it was for the engineer, 115.

Lewis, W. B., remarks as to the question of gauge having been debated in the colony of Victoria, 162, 163.—Ditto as to the evidence of Mr. T. Higinbotham, Engineer-in-Chief of the Government railways in Victoria, on that question, and as to the plans and estimates prepared, 162.—Ditto as to the fallacy of arguing upon averages, 163.—Ditto as to the cost of the broad-gauge lines and of the narrow-gauge lines in Norway, 163.—Ditto as to the Legislative Assembly in Victoria, which had voted for the construction of railways on the 3 ft. 6 in. gauge, having rescinded that vote by a majority of four to one, 164.

Mitchell, J., remarks as to the Dingwall and Skye railway, [illegible] tenders for making that line on the 3 ft. 6 in. gauge, and on the 4 ft. [illegible], 187.

Norway, railways of, 35 *et seq.*, 60, 61, 145.

Ormsby, A. S., remarks as to the gradual and permanent alteration of the Indian gauge to one of 3 ft. 6 in., 159.

Pihl, C., remarks as to the narrow-gauge railways, and broad-gauge railways in Norway, 60, 61.—Ditto as to break of gauge, 61.—Ditto as to the change of gauge and rolling-stock of the Great Western railway in England, 61, 62.

Pole, W., remarks as to the alteration of the gauge of railways in India, 218, 223.—Ditto as to the influence the gauge had on the cost of a railway, and as to the real criterion of expense being the carrying power, 219.—Ditto as to the Great Western railway, and as to the extra cost of making that line on the broad gauge, 219.—Ditto as to the assumed economy of construction of narrow-gauge railways, 219.—Ditto as to the introduction of the 'overhang' of the carriages having taken away the significance of the gauge as a measure of the works, 219, 220.—Ditto as to the unmechanical step of pushing the wheels closer together under the middle of the carriage, 220.—Ditto as to 'light railways,' 220.—Ditto as to the cost of a line 22 miles long, constructed to accommodate a poor district, 220.—Ditto as to a light branch line on the Great Western railway system, 221.—Ditto as to a light railway on the standard gauge, called the 'Wotton Tramway,' 221.—Ditto as to the traffic on ditto, 221.—Ditto as to the Rigi railway, near Lucerne, 221.—Ditto as to light railways having been provided for by the legislature, 222.—Ditto as to a Report of a Meeting of the Exeter Chamber of Commerce, in June, 1872, on the subject of light railways to Exeter and the neighbourhood, 222.—Ditto as to the assumption that practically the broad gauge was never adopted, except when broad, heavy vehicles were used, 222.—Ditto as to a statement by Mr. Gladstone in the House of Commons with regard to the victory of the narrow gauge over the broad gauge, 222.—Ditto as to break of gauge, 223.—Ditto as to the Imperial railways of Japan, 223.—Ditto as to the proposed narrowing of the gauge in India being founded on a delusion, 223.

Rendel, A. M., remarks as to the Committee appointed by the Government in 1870, to consider the question of gauge, 144, 145.—Ditto as to the railways in Norway on a 3 ft. 6 in. gauge, 145.—Ditto as to the heating surface of narrow-gauge engines, 145.—Ditto as to the reasons for adopting the mètre as the gauge for the State railways of India, 145, 146, 147.—Ditto as to a report signed by Colonel Strachey, Colonel Dickens, and himself, recommending a 2 ft. 9 in. gauge and a 36-lbs. rail, 146.—Ditto as to the arguments for retaining the 5 ft. 6 in. gauge, and reducing the weight of the rails, 147, 148. —Ditto as to the failure of a 42-lbs. rail on the Oudh and Rohilkund railway, 147.—Ditto as to the officials of Indian railways and the Government, 148.—Ditto as to the narrow-gauge system as applied to the Scinde and Peshawur lines, 149, 151.—Ditto as to the question of the Scinde railway competing with the navigation on the Indus, 150.—Ditto as to his estimates in respect to the Indian narrow-gauge lines, 151, 152.—Ditto as to the sidings on the Scinde railway, 152.—Ditto as to the policy of the Government in laying the Peshawur line alongside the road, 152.—Ditto as to the difference between English and Indian traffic, and the effective capacity of Indian railways, 153.—Ditto as to the mètre-gauge rolling-stock, 154.—Ditto as to the mètre-gauge horse-boxes, 155. —Ditto as to break of gauge, 156.—Ditto as to the cost of transhipment, 156.—Ditto as to a diagram showing the increase of traffic upon Indian railways, 157.

Sandberg, C. P., remarks as to a discussion in respect to the continuation of the standard (4 ft. 8½ in.) gauge in Sweden, 126.—Ditto as to the result being that the standard gauge was continued, but with a lighter construction necessitating a lower speed, 126.—Ditto as to the little support given to the narrow gauge in Sweden, 126.—Ditto as to an "Account of the Swedish railways, their Cost, Gauge, and Speed," 127.—Ditto as to a communication from Baron von Weber in respect to the construction of branch lines in Austria on the normal gauge of 4 ft. 8½ in., 127.—Additional memoranda as to the Swedish railway system, 309.

Simmons, Sir L., Lieut.-General, R.E., remarks as to the saving to be effected by the adoption of the narrow gauge, 197.—Ditto as to the question being one for the comparison of prime cost, in conjunction with that of the relative expense and inconvenience of working the two gauges, 197.—Ditto as to the inconvenience and difficulties occasioned by a break of gauge, 197, 198, 199, 200, 201, 202.—Ditto as to the probable increase of traffic passing through Lahore, 197, 198.—Ditto as to the increase of traffic in England, 197.—Ditto as to the military aspect of the question of break of gauge in the great strategic lines of communication throughout India, 198, 199, 200, 201.—Ditto as to the effect of the destruction of the narrow-gauge rolling-stock of the Punjâb railways, 199.—Ditto as to the German military operations in France, and as to the advantage derived from the use of German rolling-stock on French railways, 200, 201.—Ditto as to the assertion that, in India, large bodies of troops would not require to be moved, 200.—Ditto as to the aggravation of the sufferings of the sick and wounded by a break of gauge, 200.—Ditto as to the use of the broad-gauge rolling-stock on light broad-gauge lines, 201.

Smith, H. Lee, remarks as to his estimates for the Peshawur railway and for the Indus Valley railway, 77, 95.—Ditto as to the adoption of the narrow gauge upon the Indian State railways having arisen from an exaggerated idea of its economy, 78, 83.—Ditto as to the 'completion statements' of a district of the East Indian railway, 79.—Ditto as to the bridges on the Peshawur line, 82.—Ditto as to the adoption by the Government of a break of gauge in the Indian railway system, 82.—Ditto as to the amount of rolling-stock requisite for working the narrow-gauge system in India, 83, 84, 85, 86, 92, 94.—Ditto as to the 'Great Runn of Cutch, 90.—Ditto as to Scinde, 90.—Ditto as to Ajmere, 90.—Ditto as to the Indus Valley railway, 95.—Ditto as to the estimated cost of constructing ditto with a 5 ft. 6 in. gauge, and with a mètre gauge, 96.—Ditto as to the Peshawur railway, 98.—Ditto as to the estimated cost of constructing ditto with a 5 ft. 6 in. gauge, and with a mètre gauge, 99, 100.

——, J. T., Colonel, R.E., remarks as to the relative amount of the working expenses on the different gauges, 188.—Ditto as to any excess in working expenses on the narrow-gauge lines being equivalent to interest on greater first cost of broad-gauge lines, 188, 190.—Ditto as to the Festiniog railway, 189, 190.—Ditto as to the consumption of fuel on ditto, 189.—Ditto as to the working expenses per train mile being 66 per cent. over the average of four English lines, 190.—Ditto as to the comparative saving in first cost and in working expenses of a light broad-gauge line and of a narrow-gauge line with vehicles of the same dimensions, 190.—Ditto as to the adoption of light vehicles and light rails laid on the 5 ft. 6 in. gauge, to be pushed forward as the traffic was developed, 191.—Ditto as to the statement that the existing guaranteed Indian lines had proved to be a commercial failure, 191.—Ditto as to an increase in

the Indian revenues, during the last fifteen years, being in a great measure attributable to the railways, 191.

Spooner, C. E., remarks as to the cost of the mètre-gauge railways, compared with that of the 5 ft. 6 in. gauge railways already constructed in India, 109, 110, 111.—Ditto as to the Indian railways being a commercial failure, 110.—Ditto as to the transhipment of traffic, 111, 112.

Strachey, R., Major-General, R.E., remarks as to the fitness of English civil engineers to decide upon the course taken by the Government in adopting the narrow gauge in India, 44.—Ditto as to the Government of India being more or less directly charged with want of due regard to professional considerations, based on English experience, 44.—Ditto as to English civil engineers not possessing such a knowledge of Indian local conditions, or of the practical administration of a great country, as would render their opinion more than one of the elements in the consideration of railway questions in India, 45.—Ditto as to the serious financial failure of the Indian railway system, 45.—Ditto as to the grounds on which the Government of India had resolved to adopt the narrow gauge for the railways between Lahore and Peshawur, and between Mooltan and Kotree, 45.—Ditto as to the supposed superior economy of the narrow-gauge system, 45.—Ditto as to the traffic likely to be brought upon the mètre-gauge lines, 46.—Ditto as to the total and average traffic of the East Indian railway, 46.—Ditto as to the capability of narrow-gauge lines for carrying the heaviest existing, or probable traffic upon them, whether merchandise, military equipments, or stores, 46, 47. —Ditto as to the cost of the mètre-gauge lines as compared with the Indian standard-gauge lines, 47.—Ditto as to the question which the Indian Government had to decide in accepting a narrow gauge, 48.—Ditto as to the construction of the Lahore and Peshawur line, 48.—Ditto as to the actual saving which would result from the adoption of the narrow gauge on the Lahore and Peshawur, and on the Indus Valley, railways, 48.—Ditto as to the effects of a break of gauge, 49, 50, 51.—Ditto as to the cost of transfer at Lahore, 50.—Ditto as to the effect of break of gauge on possible military operations in the Punjâb, 50.—Ditto as to the disadvantages of a single line of railway for moving large bodies of troops, &c., 51.—Ditto as to the policy of the Government as regards the suppression of railway companies and the change of gauge in India, 51.—Ditto as to the development of narrow-gauge railways in the southern parts of the United States of America, 52.—Ditto as to proposals made that broad-gauge lines should be constructed with light rails, 52, 53.—Ditto as to the carrying capacity of the narrow-gauge vehicles for Indian traffic, 53.—Ditto as to the amount of rolling-stock requisite for working the narrow-gauge system in India, 84.—Ditto as to the evils which had arisen from the system of railway guarantees in India, 122.

Tanner, J. E., remarks as to the dividend earned by the guaranteed railways of India, and as to the advantages reaped by the Indian Government and by the tax-payers, 223.—Ditto as to the skilled labour taught by the guaranteed railways having become remunerative to the country, 224. —Ditto as to the disadvantages contended with in the course of construction of some of the railways, 224, 226.—Ditto as to the postal service of India, and as to the saving effected therein by the construction of the guaranteed railways, 224.—Ditto as to the economy accruing to the Government by moving troops by rail, 224.—Ditto as to break of gauge, 224.—Ditto as to the

Sutlej bridge, 225.—Ditto as to the comparative cost of a narrow-gauge line and of a broad-gauge line, 225.—Ditto as to two estimates for a single line of railway in one of the colonies, one on a gauge of 3 ft. 6 in., and another on a gauge of 4 ft. 8½ in., 225.—Ditto as to the data started with, 225.—Ditto as to the result of the estimates, 225, 226.—Ditto as to the rolling-stock of the two gauges, and as to the comparative cost of ditto, 226.—Ditto as to the traffic estimated for, 226.—Ditto as to the carrying capacity of the narrow-gauge wagons and of the broad-gauge wagons, 226.—Ditto as to the result of the estimates being in favour of the 4 ft. 8½ in. gauge, 226.—Ditto as to the desirability of arriving at a true comparison of the cost of narrow-gauge railways and of broad-gauge railways in India, 226.—Ditto as to the statement that none of the Engineers of the Indian lines suggested the construction of light or cheap lines, 227.—Ditto as to his having proposed a light railway so early as 1861, 227.—Report on a light railway to connect the larger towns of the Punjâb with Lahore, dated December 6, 1861, 323.

Thornton, W.T., C.B., the relative advantages of the 5 ft. 6 in. gauge and of the mètre gauge for the State railways of India, and particularly for those of the Punjâb, 3.—The one solitary reason of the Indian Government for adopting a narrow gauge was belief in its superior economy, 3.—Editorial note drawing attention to material corrections made by the Author and speakers in the course of the discussion, consequent upon a considerable over-statement of the number of miles of State railways projected, 3.—Abstract proposition that a narrow-gauge railway must be cheaper than a broad-gauge railway, 4.—Assumed saving in special items, 4.—Estimated saving by Mr. Hawkshaw and by Mr. Fowler, 4, 5.—Programme of the Indian Government for State railways, 6.—Transport of the utmost amount of expected traffic not beyond the capacity of the mètre gauge, 6.—Position of the Indian Government when first conceiving its State railway policy, 7.—Amount previously expended by railway companies, 7.—Interest guaranteed, earnings, and deficiency to be made up by the Indian tax-payers, 7.—Choice of Government laid between narrow-gauge railways and no railways at all, 8.—As to the opinion that, owing to particular circumstances, the broad gauge would be better adapted to particular localities, and especially to the Punjâb railway system, 8.—Arguments in support of that opinion by Mr. Fowler, 8.—Estimates by Mr. Fowler and by Mr. Lee Smith for railways from Peshawur to Lahore, and from Mooltan to Kotree, 9.—Estimated total saving by the adoption of the mètre gauge on those two sections, 10.—Recommendations by Mr. Fowler, 10.—As to the alleged necessity of providing additional rolling-stock, 11.—Comparisons hitherto made by Mr. Fowler or others, between broad gauge and narrow gauge for the Punjâb, 11.—Purposes which the Punjâb system of railways has in view rather strategical than commercial, 12.—Necessity for a branch from Sukkur, on the Indus, to Dadur, at the mouth of the Bolan Pass, 12.—Connection of the Indus Valley railways with those of Rajpootana, 12.—As to what extent a large pecuniary advantage would be counterbalanced by the disadvantages consequent on break of gauge, 12.—Evil attendant on break of gauge, 13.—Ditto in the case of the Punjâb considered in its mercantile and strategical aspects, 13, 14, 15.—Quantity of traffic passing through Lahore in 1870-71, 14.—Respecting the restriction of the projected Punjâb lines to their own proper rolling-stock, and their inability to borrow from their own proper rolling-stock, 15, 16.—Case for the Government of India, 16.—Remarks as to the amount of rolling-stock requisite for working the narrow-gauge system in India, 84.—Ditto as to arguments against the adoption

of the narrow gauge in India, 227, 228, 237, 242, 243, 248, 249.—Ditto as to the estimates of Mr. Fowler and of Mr. Hawkshaw, 229.—Ditto as to the mode in which the assumed total average saving per mile, to be effected by the adoption of a light mètre gauge, was obtained, 230.—Ditto as to the exception taken to the details of which that total was composed, 230.—Ditto as to the item of land and as to the variable price of land in India, 230, 231.—Ditto as to the item of earthwork, 231.—Ditto as to the item of bridges, 231.—Ditto as to the items of sleepers and of ballast, 231, 235.—Ditto as to the saving on engineering and agency, 232.—Ditto as to reduced cost of annual repairs of a narrow-gauge line, 232.—Ditto as to the question of saving by the use of sharper curves on a narrow-gauge line, 233, 234.—Ditto as to the total saving per mile to be obtained by the adoption of the narrow gauge, 236.—Ditto as to the weight assumed for the rails, 236.—Ditto as to break of gauge, 238, 247, 249.—Ditto as to the traffic upon the railways in India, 238.—Ditto as to exaggerated notions of the disadvantages of break of gauge which had been deduced from English experience, 238, 239, 240, 241.—Ditto as to the number of miles of railway already constructed or in process of construction to provide India with a complete network of railways, 241.—Ditto as to a despatch recently received from the Government of India, in reply to one from the Secretary of State, containing an estimate of the probable cost of altering the gauge of the Punjâb system, 243, 244.—Ditto as to no additional rolling-stock being required by reason of the adoption of the mètre gauge on the Lahore-Peshawur line, 245.—Ditto as to the traffic on the Lahore-Mooltan line, 246, 247.—Ditto as to the saving consequent on the adoption of the mètre gauge for the Punjâb system, 247.—Ditto as to the effect of the adoption of the narrow gauge upon military movements, 249, 250.—Ditto as to the capacity of the mètre-gauge vehicles to carry field artillery, 251.—Ditto as to the numerical sufficiency on extraordinary emergencies of the rolling-stock of the Punjâb railway system, 251, 252.

Turnbull, G., remarks as to the question of Indian railways in itself being one of a technical character, 216.—Ditto as to the adoption of the narrow gauge and the introduction of the mixed gauge, 216.—Ditto as to the objections to a break of gauge and to a mixed gauge, 216, 218.—Ditto as to the estimates of the saving to be effected by the adoption of the narrow gauge, 216, 217.—Ditto as to the question of maintenance, 216.—Ditto as to the question of the cost of construction, and as to the proposed saving being illusory, 216, 217.—Ditto as to the adoption of a light broad gauge where light traffic occurred, 217.—Ditto as to the desirability of adopting the narrow gauge in some localities in India, 217.—Ditto as to the want of 'feeders,' or roads of communication leading to the railway stations, 218.

Tyler, Captain H. W., remarks as to the circumstances under which broad-gauge railways or narrow-gauge railways were respectively suited, 104.—Ditto as to the necessity that, in a comparison of cost as between two gauges, the precise line of railway and its peculiar circumstances should be indicated, 105.—Ditto as to the fallacious results obtained from averages, 105, 106.—Ditto as to the comparative cost and efficiency of working and of maintenance as between two gauges depending upon the character and quantity of the traffic and upon the speed required, 106.—Ditto as to the disadvantages of break of gauge, and as to ditto on the Grand Trunk railway of Canada, 107.—Ditto as to the difficulties of embarking and disembarking bodies of troops when transported by railway, 107.—Ditto as to the necessity for reconsidering the question of the adoption of the mètre gauge for the State railways of India, 108, 109.

Victoria, colony of, report made by Mr. W. W. Evans against the use of the narrow gauge for the railways of, 122.
Vignoles, C. B., Past-President, remarks as to a report made by him, in September, 1842, as to the desirability and possibility of making railways in India, 118, 264. —Ditto as to the report made by the Irish Railway Commissioners, 119.—Ditto as to the mètre not being a scientific, but an arbitrary unit of measurement, 120. —Ditto as to the assumed saving by the adoption of the mètre gauge for the State railways of India being illusory, 120.—Ditto as to the construction of efficient and cheap railways upon the existing Indian standard gauge, 120.—Ditto as to railways having contributed to increase the land revenue of India, and as to the duty of the State to expend money in public works upon other considerations than those which govern a private capitalist, 120, 121.—Ditto as to the past and present deficiency of ordinary roads, and as to the necessity for their construction by the Government, as feeders to the railways, 121.—Ditto as to a report made by Mr. W. W. Evans (of New York) against the use of the narrow gauge for the railways of the British colony of Victoria, 122.—Report on the Hindustanee railway, dated September 22, 1842, 264.

War, Franco-Prussian, arrangements made by the Germans during, for the supplies of their army in France, 175.
Weber, Baron M-M. von, reference to a communication from, in respect to the construction of branch lines in Austria on the normal gauge of 4 ft. 8½ in., 127.
Williams, R. Price, remarks as to the adoption of narrow-gauge lines, 128.—Ditto as to the Lahore-Peshawur railway, 128.—Ditto as to the Indus Valley railway and the Mooltan-Kotree railway, 129.—Ditto as to the estimated saving by the adoption of the narrow gauge, 129, 133, 134, 135, 137, 143.—Ditto as to the circumstances under which the broad gauge was adopted, 129.—Ditto as to a proposed light railway on the standard gauge in the West of Ireland, 129.—Ditto as to an estimate of the comparative cost per mile of ditto, on a 5 ft. 3 in. gauge, and on a 3 ft. 6 in. gauge, 130.—Ditto as to the relative cost of maintenance and renewals on both those gauges, 131.—Ditto as to the life of rails and of sleepers, 132.—Ditto as to the construction of rolling-stock for railways on the broad gauge and on the narrow gauge, 135.—Ditto as to the running expenses on the narrow gauge, 136.—Ditto as to the ratio of the dead load to the paying load being identical on the broad gauge and on the narrow gauge, 136.—Ditto as to the narrow gauge being more expensive in maintenance and renewals, 137. —Ditto as to the difference in the circumstances of light railways in Great Britain and in India, 137.—Ditto as to the amount of the population of India served by the railways, 138.—Ditto as to the progressive development of traffic on the Indian railways, 138, 139.—Ditto as to a diagram showing the increase of traffic on ditto, from 1861 to 1872 inclusive, 138, 139.—Ditto as to a table in respect to the Inman railways showing the increase per cent. of mileage opened, passengers conveyed, and receipts from passenger traffic, goods traffic, and total traffic, from 1862 to 1871 inclusive, 140.—Ditto as to a diagram showing the increase of traffic on the railways of the United Kingdom, from 1849 to 1871 inclusive, 141. —Ditto as to a statement showing the increase per cent. of the gross receipts and miles of line of the railways of the United Kingdom, from 1849 to 1871 inclusive, 142.—Ditto as to the important bearing of the actual growth of the Indian railway traffic, 142.—Ditto as to the evil effects of break of gauge, 143.—Ditto as to the South Wales coal having been hitherto excluded from the London market owing to the break of gauge on the Great Western railway system, 143.

Wood, J. T., remarks as to the question of military transport, 169, 170.—Ditto as to the question whether the capacity of the mètre gauge was sufficient for the traffic of the existing 5 ft. 6 in. gauge, 171, 172.—Ditto as to facilities for the interchange of rolling stock and for the transport of goods liable to handling, 171, 173.—Ditto as to the evils of break of gauge on the Eastern Bengal railway, 172.—Ditto as to dead weight and as to the consumption of coal by a train when full and when empty, 173.—Ditto as to the rates and fares of the guaranteed railways in India, 173.—Ditto as to the system of average rates and fares charged for railway transport in India, 173.—Ditto as to the obligation of the Indian Government to make and repair the ordinary roads, 174.—Ditto as to the causes to which the deficit on the guaranteed railways might be attributed, 174.

Woods, E., remarks as to the abstract proposition that a narrow-gauge railway must be cheaper than a broad-gauge railway, 192, 194.—Ditto as to narrow-gauge lines having been more costly than broad-gauge lines, owing to the nature of the traffic to be provided for, 194.—Ditto as to the fallacy that the cost of lines might be computed to be in proportion to the width of gauge, 194.—Ditto as to the mistake originally made by the Indian Government in sanctioning the formation of lines equal to the first-class English railways, 194.—Ditto as to the large and unnecessary outlay occasioned by the establishment of a wider gauge than was necessary, even in England, 194.—Ditto as to the railways of the United States and of the Spanish Republics of the South American continent, 194.—Ditto as to the gauges of the railways in the United States, in Peru, in Chili, and the Argentine Republic, 194.—Ditto as to the cost of a line in the latter country constructed on the 5 ft. 6 in. gauge, 194.—Ditto as to the proposed change of gauge in the colony of Victoria, 195.—Ditto as to the saving to be effected by the adoption of a 3 ft. 6 in. gauge, in lieu of a 5 ft. 3 in. gauge on a proposed line in that colony, 195.—Ditto as to the proportion of constant and variable expenses, 195.—Ditto as to the dimensions of the vehicles and the weights they were required to carry being the determining elements of the width of gauge, &c., 195.—Ditto as to the change of gauge in India, and as to the introduction of breaks of gauge, 195, 196.—Ditto as to the adoption of light lines and of light rolling-stock, 195.—Ditto as to the increase in working expenses on the mètre gauge, 196.—Ditto as to the change of gauge on the Great Western railway, 196.—Ditto as to the evils incidental to breaks of gauge, 196.

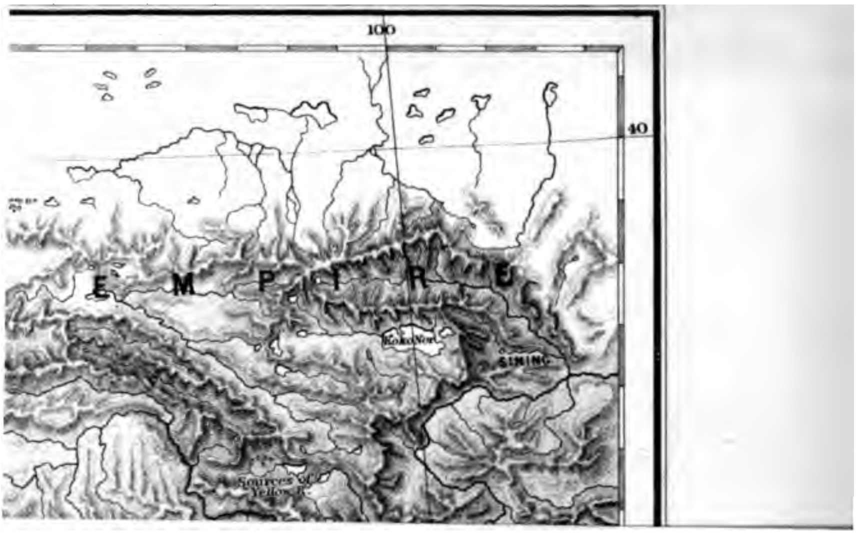
Yolland, W., Colonel, R.E., remarks as to the original selection of a 5 ft. 6 in. gauge instead of a 4 ft. 8½ in. gauge for the main trunk lines in India, 158.—Ditto as to the abrupt substitution of the 3 ft. 6 in. gauge, or of the mètre gauge, 158.—Ditto as to the cost of construction of ditto, 158.—Ditto as to the introduction of sharp curves with traffic conducted at a moderate speed, 158.—Ditto as to the undesirability of making any change in the gauge of the main trunk lines of India, 158.

Young, E. W., remarks as to a railway of 3 ft. gauge in Nova Scotia, and as to the rails and rolling-stock used on ditto, 202.—Ditto as to the curves on ditto, 202.—Ditto as to the capabilities of narrow-gauge lines, 202.—Ditto as to the superiority of the narrow-gauge system over the light broad-gauge system, 203.—Ditto as to the trivial character of the objection to a break of gauge, 203.—Ditto as to the carrying capacity of narrow-gauge lines being dependent upon the amount of rolling-stock at hand, 204.—Ditto as to the percentage

of working expenses on the narrow-gauge system being less than on the broad-gauge system, 204.—Ditto as to the want of ordinary roads in India, and as to whether wooden tramroads, on which the wagons of the mètre gauge could be drawn, would not be found cheaper in construction and maintenance than ordinary roads, 204.—Ditto as to the suitability of the narrow-gauge system to India, 204.

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET
AND CHARING CROSS.

PLATE 8



INDIAN RAILWAYS.

THE BROAD- AND THE NARROW-GAUGE SYSTEMS CONTRASTED.

BY

FRANCIS JOHN WARING, M. Inst. C.E.

WITH AN ABSTRACT OF THE DISCUSSION UPON THE PAPER.

EDITED BY

JAMES FORREST, Assoc. Inst. C.E.,

SECRETARY.

By permission of the Council.

Excerpt Minutes of Proceedings of The Institution of Civil Engineers.

Vol. xcvii. Session 1888–89. Part iii.

LONDON:

Published by the Institution,

25, GREAT GEORGE STREET, WESTMINSTER, S.W.

[Telegrams, "Institution, London." Telephone, "3051."]

1889.

ADVERTISEMENT.

The Institution as a body is not responsible either for the statements made, or for the opinions expressed, in the following pages.

LONDON: PRINTED BY WM. CLOWES AND SONS, LIMITED, STAMFORD STREET AND CHARING CROSS.

THE INSTITUTION OF CIVIL ENGINEERS.

SECT. I.—MINUTES OF PROCEEDINGS.

12 March, 1889.

SIR GEORGE B. BRUCE, President,
in the Chair.

(*Paper No. 2324.*)

"Indian Railways. The Broad and the Narrow-Gauge Systems Contrasted."

By FRANCIS JOHN WARING, M. Inst. C.E.

THE object of this Paper is to discuss the comparative cost of constructing and working railways on the gauges of 5 feet 6 inches and of 1 metre. Sixteen years ago a memorable controversy took place within the walls of this Institution upon a Paper by Mr. W. T. Thornton, C.B., Secretary of the Public Works Department, India Office, on "The Relative Advantages of the 5 feet 6 inches Gauge and of the Metre Gauge for the State Railways of India, and particularly for those of the Punjab." [1]

It is thought that the arguments then adduced in favour of the building of all future railways in India on the metre gauge, on the ground of economy, both in construction and working; and also the arguments in opposition to the introduction into that country of the break of gauge, are so well known that they need not be repeated.

It is deemed needless to follow Mr. Thornton and his supporters in the application of their principles to the particular cases of the Indus Valley and the Punjab Northern Railways, inasmuch as by making these railways upon the 5 feet 6 inches gauge, it may be assumed that the reasons for maintaining uniformity of gauge, which were then ignored by the advocates of the narrow gauge, were shortly afterwards found to be so cogent, as to outbalance any anticipated economy to be effected by adopting the metre gauge for those lines. The Author, however, believes that, after this lapse of years, it may be interesting to institute an inquiry into the statistics of the construction and working of Indian railways, founded on the Administration

[1] Minutes of Proceedings Inst. C.E., vol xxxv. p. 214.

Reports, with the view of testing, by the results of experience, the soundness of the views then expressed on both sides of the question. This, then, is the object of the present Paper. At the outset, a few remarks upon the history and growth of the Indian Railway system, which is now approaching in magnitude that of the United Kingdom, and which bids soon to surpass it, may not be out of place.

Commencing on the 18th of April, 1853, with the opening of the first section of the Great Indian Peninsula Railway, between Bombay and Thána, a distance of 20¼ miles, the system has expanded until, on the 31st of March, 1887, the total length opened for public traffic was 13,390¼ miles, while an additional length of 3,205¾ miles was in progress or had been sanctioned for construction.

Taking quinquennial periods, the following Table shows the growth of the system:—

Year.	Miles Open for Traffic.	Miles Opened in each Quinquennial Period.
1853	20¼	
1858	428½	408¼
1863	2,550	2,121½
1868	4,016¼	1,466¼
1873	5,695	1,678¾
1878	8,212	2,517
1883–84	10,780¼	2,568¼
1886–87	13,390¼	2,610

The gauge of all the earlier lines, constructed by guaranteed companies, was 5 feet 6 inches, the first departure from it being in the case of the Nalháti Railway, built by the Indian Branch Railway Company, now the Oudh and Rohilkhand Railway Company, on half the public road between Nalháti and Azimganj on a gauge of 4 feet. This line was opened on the 21st of December, 1863, and still remains the solitary example in India of a railway on that gauge.

This departure from the standard remained an isolated instance until the 14th of January, 1873, at which date 5,576¼ miles of railway of the 5 feet 6 inches gauge were in existence, when

the first section of the Rajputana-Malwa metre-gauge State Railway was opened.

Classified by gauges, the present railways may be thus subdivided:—

Gauge.		Total Miles Open.	Miles laid with Double Line.
Feet.	Ins.		
5	6	7,987¾	905½
4	0	27¼	
3	3⅜	5,117	1¼
2	6	177¾	
2	0	80½	
Totals .		13,390¼	906¾

It thus appears that notwithstanding the inability, on the ground of expense, professed by the Government of India in 1873 to continue the construction of railways upon the 5 feet 6 inches gauge, no less than 2,411½ miles of line of that gauge have since been opened for traffic; and it is noteworthy that of the mileage, now sanctioned or being constructed, no less than 1,741¼ miles, or more than 54 per cent., are to be on the same gauge.

The following is a classification of the Indian railways according to their proprietorship and management:—

——	Mileage on the 31st of March, 1887.	Miles laid with Double Line.
State Imperial—		
In hands of companies	3,816	470¾
" " the State	2,501¾	25¾
State Provincial—		
In hands of companies	413¾	
" " the State	1,221	
Guaranteed railways	3,895¾	410¼
Assisted companies	593¾	
Other companies	48¾	
Native States—		
In hands of companies	498¾	
" " the State	400¾	
Totals	13,390¼	906¾

Of the railways under construction, 245 miles are in the hands of companies, 2,453¾ are in the hands of the State, and 507 miles are being built by Native States.

The total capital outlay, including expenditure on the connected

steam-boat services, amounted on the 31st of December, 1886, to £170,498,911,[1] at the conventional rate of 2*s.* per rupee, of which £60,763,058 had been spent by guaranteed companies, £100,780,534 on State railways, including the East Indian Railway, which stands at £35,221,312, £3,423,367 on assisted companies lines, and £5,531,952 on Native States lines. The gross receipts in 1886 were £18,704,536, and the working expenses £8,930,983, thus leaving a net revenue of £9,773,553,[2] of which the East Indian and branches contributed £3,133,232, the guaranteed lines £3,654,183, the assisted lines £124,003, the State lines, Imperial and Provincial, excluding the East Indian Railway, £2,702,533, and the Native State lines £159,602.

The total net return on all lines in 1886 was £5 14*s.* 8*d.* per cent.,[3] or, excluding steam-boat and suspense items, £5 18*s.* 1*d.* The East Indian Railway and branches produced £8 8*s.* 11*d.* per cent., the Guaranteed lines £6 0*s.* 3*d.* per cent., the State lines, excluding the East Indian, £4 4*s.* 8*d.* per cent., the Assisted lines, excluding the Tárakeshwar Railway, £3 16*s.* 3*d.* per cent., and the Native State lines £2 17*s.* 8*d.* per cent.

The total number of passengers was 88,436,318, and the receipts from coaching traffic were £5,793,152,[4] while the aggregate tonnage of goods was 19,576,365 tons, the receipts being £12,385,914.

The annexed diagram (Fig 1) shows the gradual growth of the mileage open, the gross receipts, the working expenses and the net earnings, of all the Indian railways from 1853 to the end of 1886.

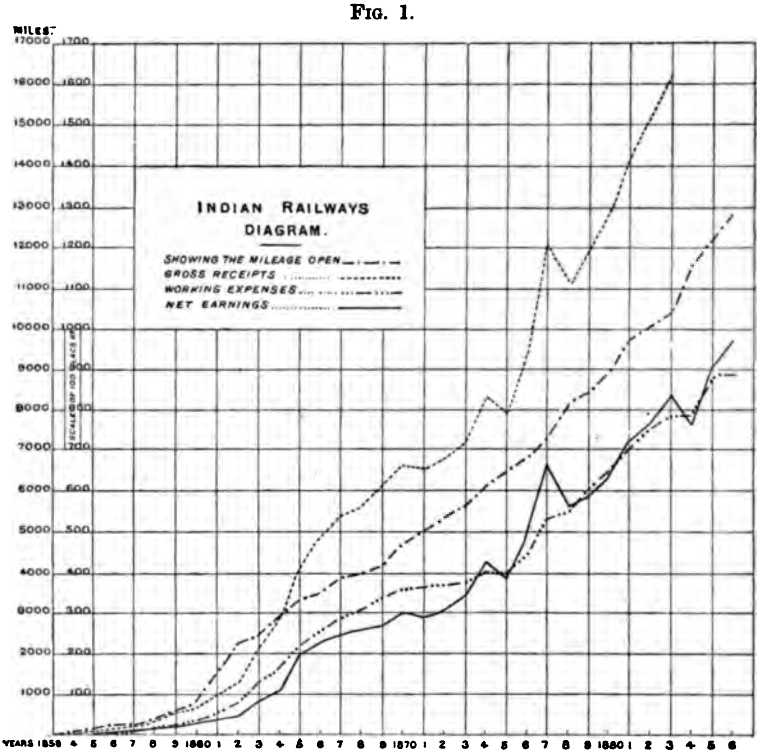
[1] As compared with £90,000,000 in 1873.
[2] As compared with £2,840,000 in 1873.
[3] As compared with less than 3 per cent. in 1873.
[4] Divided among classes the numbers and proportions are:—

—	Number.	Proportion of Total No. per cent.	Receipts.	Proportion of Total Receipts per cent.
			Rupees.	
First class	386,102	0·44	1,982,464	3·42
Second class	2,082,295	2·35	3,079,770	5·32
Third or intermediate class	3,395,726	3·84	3,206,151	5·53
Fourth or lowest class	82,572,195	93·37	42,708,623	73·72
Other coaching traffic	..	..	6,954,510	12·00
Totals	88,436,318	100·00	57,931,518	99·99

Having thus dealt in general terms with the Indian railway system as a whole, it is intended in the remainder of this Paper to consider separately, and to compare, certain statistics connected with the cost of construction and of working of the lines of 5 feet 6 inches gauge, with similar figures relating to narrow-gauge lines.

The capital outlay upon construction, per mile of railway open, taking all the railways in India for which separate accounts appear

FIG. 1.



to have been kept, has varied, in the case of lines of 5 feet 6 inches gauge, from Rs. 210,686 on the East Indian to Rs. 35,929 on the Pátri Railway.

Upon the metre-gauge lines, this expenditure has varied between Rs. 87,235 on the Northern Bengal Railway and Rs. 17,271 on the Jodhpore Railway; while upon railways of other gauges the maximum capital outlay of Rs. 52,609 per mile occurs in the case of the Darjeeling-Himalayan Railway of 2 feet gauge, and the minimum of Rs. 11,967 on the Nalháti line of 4 feet gauge.

In railways having the same gauge, these large variations in mileage cost can only be accounted for by some difference in the class of railways made, and by the presence or the absence of difficulties and costly works encountered in their construction.

While comparing the mileage cost of lines on the 5 feet 6 inches gauge with that of lines on narrower gauges, it is evident that since the advocates of the reduction of the gauge to a metre hesitated to place the anticipated saving at a higher amount than £1,000 per mile, and that even this sum was considered excessive by the speakers in the discussion upon Mr. Thornton's Paper, who objected to the proposed change; much of the economy effected in the construction of the narrow-gauge lines must, in this case also, be largely due to some inferiority in the class of railway made, possibly conjoined to the comparative absence of engineering difficulties in making them.

Contrasting the broad-gauge lines with those of narrow-gauge, the Author will briefly consider to what extent the views just expressed are borne out by facts. As regards the former, which may be described as the main arterial communications throughout India, not only is a double line of way laid on more than 11·3 per cent. of their total length; but over a large portion of the remainder, the earthworks have been formed, and in many cases the bridges and culverts, excepting only the girders, have been erected for its reception. Although the policy of making these provisions for doubling the lines, at dates admittedly before the traffic rendered the laying of a double line of way necessary, may be open to difference of opinion, it is manifest that they can better, more economically, and more conveniently, be arranged during the construction of the line than at any subsequent period; and it is thought that this will go far to outweigh any loss of interest on unproductive capital which has thus been entailed.

Looking at the fact that, of the total distance of 1,409¼ miles between Bombay and Calcutta, 751½ miles have already been laid with a double line of rails, and that another section of 77 miles between Bhusáwal and Khandwa, on the Great Indian Peninsula Railway, is now being doubled, probably in a few years there will be a complete double line between Bombay and Calcutta, and the increase of traffic will render necessary the doubling of the line between Allahabad and Lahore, if not also from the latter place to Kurrachee. Upon the metre-gauge lines only 1¼ mile of double-line has been laid, and no preparation upon the remainder of the railways of that gauge has, so far as the Author knows, been made for it. The rails upon the broad-gauge lines, in man cases

of steel, weigh from 60 to 84 lbs. per lineal yard. These lines are, almost without exception, well ballasted and fenced; ample station accommodation is provided, and in many other respects their finish is equal to that of English railways.

Upon the metre-gauge lines—which, with the exception of the Rajputana-Malwa State Railway, may be described as subsidiary or feeders to the broad-gauge lines, the rails, generally of steel, do not in any case weigh more than 41¼ lbs. per lineal yard; though upon the railway just mentioned all future renewals are to be made with 50-lb. steel rails. The traffic anticipated being less, smaller station-accommodation was provided, and on some of the less important lines and branches, either ballasting or fencing, or both, have been omitted.

Some of the leading dimensions, &c., affecting the railways, as prescribed in the Government regulations for railways of both these gauges, are given in the Table (p. 10).[1]

As regards railways of other gauges, it is only necessary to state that, in many cases, they have been laid on existing cart-roads. It is noteworthy that the Darjeeling-Himalayan Railway, which traverses a difficult country, was, it is believed, for 80 per cent. of its length, thus laid on a road, and that the estimate for a railway of that gauge, namely, 2 feet, between Kalka and Simla, through a similarly difficult country, where it is assumed that no road was available, is at the rate of Rs. 90,692 per mile. Appendix Table I contains a list of all railways in India opened or sanctioned; their gauges, lengths, length laid with double line, their capital cost per mile; return in 1886 upon the capital, and a few leading particulars of each.

Omitting works of such difficulty and magnitude as the passage of the Bhore and Thul Ghâts on the Great Indian Peninsula Railway, and those encountered by the Sind-Pishin Railway, in its extension to Quetta through the mountains of Beluchistan, which, however, occur on railways of 5 feet 6 inches gauge, and to which, upon the metre-gauge lines, the only example of a similar work is found on the West of India Portuguese Railway, in the ascent of the Ghâts from Mormugão to the Portuguese frontier; the principal engineering difficulties upon Indian railways have been the crossings of the great rivers. From the nature of the case, it is evident that, upon the broad-gauge lines forming the main trunk communications of the country, the heavy expenditure entailed by bridging these rivers had to be faced, no matter what

[1] Administration Report upon Railways in India for 1882-83. Part II. Appendix K, p. clix. *et seq.*

[illegible]	Railways of [illegible] gauge	Railways of [illegible] gauge
(1) *Maximum and Minimum [illegible]*		
Minimum distance centre to centre of tracks outside platform	[illegible] feet	12 feet
Minimum distance from centre to centre of tracks in platform [illegible]	15 ,,	13 ,,
Minimum radius of curve for railways in ordinary country	1,500 ,,	1,000 ,,
Minimum radius of curve for railways in difficult country	800 ,,	600 ,,
Minimum depth of ballast below sleepers	[illegible] inches	6 inches
width ,, at top	10 ft. 6 ins.	7 feet
number of sleepers per mile	1,760	2,000
height above rail level for passenger platforms [illegible]	1 ft. 4 ins.	
[illegible] length of passenger platform [1]	600 feet	500 feet
[illegible] available length of siding at crossing [illegible]	1,600 ,,	1,300 ,,
[illegible] siding	2,000 ,,	1,600 ,,
[illegible] *to be observed as far as [illegible]*		
[illegible] embankment	20 ,,	16 ,,
[illegible] (including side drains)	18 ,,	14 ,,
[illegible] centre to centre of tracks [illegible]	14 ,,	12 ,,
[illegible] ordinary country	1 in 150	1 in 150
difficult ,,	1 in 50	1 in 50
[illegible] the live load uniformly distributed [illegible] may be assumed to be		
[illegible] span	28 tons	14 tons
[illegible]	34 ,,	22 ,,
[illegible]	46 ,,	35 ,,
[illegible]	90 ,,	60 ,,
[illegible]	107 ,,	78 ,,
[illegible]	160 ,,	110 ,,
[illegible]	213 ,,	135 ,,
and the maximum load on a single pair of wheels	14 ,,	7 ,,
[illegible] Standard length	9 ft. 11 ins.	6 ft. 0 ins.
,, breadth	10 ,,	8 ,,
,, depth	5 ,,	4 ,,
Rails Standard rail weight per yard in steel	62 lbs.	41½ lbs.
Stations, &c. Standard height above rail level for passenger platforms at important stations	3 ft. 0 ins.	1 ft. 3 ins.[2]
Do. Do. for carriage and horse landing platform	4 ,, 0 ,,	
Do. Do. for goods platforms, and for carriage and horse landing platforms on metre-gauge lines	3 ,, 6 ,,	2 ,, 3 ,,

[1] The lengths of platform and siding apply only when ruling gradient is flatter than [illegible]; when the ruling gradient is steeper they may be proportionately reduced.

[illegible] ortant stations the platform may be omitted altogether, its [illegible] slabs of stone about 3 inches above rail level.

the amount might be; whereas, upon the subsidiary narrow-gauge railways, the occurrence of any exceptional quantity of bridging upon a proposed line would, it is thought, lead to the undertaking being abandoned on account of the cost involved.

To such an extent has this apparently been the case, that out of the annexed list (Appendix, Table II), comprising forty of the largest railway-bridges in India, of an aggregate length of 113,594 feet, and having cost Rs. 99,732,535, no less than thirty-five, of an aggregate length of 103,814 feet, and having cost Rs. 92,478,064, occur upon broad-gauge lines. Dividing this latter sum among the 7,988 miles of broad-gauge railway open, it would appear that their average mileage-cost, by this item alone, has been increased by nearly Rs. 11,600; while the cost of the larger bridges upon metre-gauge railways, divided among the total open mileage of that gauge, raises the cost by only Rs. 1,416 per mile.

But the actual cost of a large bridge does not, in many cases, by any means represent the total additional expenditure involved by its occurrence. It is well known that many Indian rivers, especially those in the plains of Northern India, where most of the large bridges enumerated in the Table occur, overflow their banks annually during the rainy season. Consequently in approaching them, not only are heavy embankments, often extending several miles in length, necessary to keep the railway above flood-level; but numerous bridges, which in almost any other country than India would in themselves be termed large bridges, are required to provide a passage for the inundation waters.[1]

Enough has now been said in support of the view, that the broad-gauge lines generally are of a superior type to those of the

[1] On the Delhi Railway, with the construction of which the Author was connected, the valleys of the Beas and Sutlej subject to inundation (including that portion of them occupied by the rivers themselves) were each about 8 miles in width where crossed by the railway. In the Beas Valley the following bridges for subsidiary streams, fed by the main river and for flood waterway, were built:—

3 bridges each of	4 spans of	28	feet in the clear.		
1 bridge of	1 span of	55	,,	,,	
1 ,,	3 spans of	28	,,	,,	
1 ,,	7 ,,	28	,,	,,	
1 ,,	2 ,,	75	,,	,,	

It is believed that even this provision was inadequate, and was subsequently increased. In the Beas Valley the embankment, which was for a single line only, for several miles averaged 81,490 cubic yards per mile. In the Sutlej Valley similar provision for flood waterway was necessary, and the embankment was of similar magnitude.

Particulars.	Railways of 5 feet 6 inches Gauge.	Railways of Metre Gauge.
(1) *Maximum and Minimum Dimensions to be strictly observed.*		
Minimum distance, centre to centre, of tracks outside station	12 feet	12 feet
Minimum distance from centre to centre of tracks in station yards	15 "	13 "
Minimum radius of curve for railways in ordinary country	1,500 "	1,000 "
Minimum radius of curve for railways in difficult country	800 "	600 "
Minimum depth of ballast below sleepers	8 inches	6 inches
" width " at top	10 ft. 6 ins.	7 feet
" number of sleepers per mile	1,760	2,000
" height above rail level for passenger platforms for stations	1 ft. 4 ins.	
Minimum length for passenger platform[1]	600 feet	500 feet
" clear available length of siding at crossing stations	1,600 "	1,300 "
Do. Do., including blind sidings	2,000 "	1,600 "
(2) *Standard Dimensions, &c., to be observed as far as possible.*		
Formation, &c.—		
Standard width in embankment	20 "	16 "
" " in cuttings (excluding side drains)	18 "	14 "
" distance, centre to centre, of tracks outside stations	14 "	12 "
" ruling gradient for ordinary country. .	1 in 150	1 in 150
" " difficult " . .	1 in 50	1 in 50
Bridges (Girder)—		
For calculations, the live load uniformly distributed for a single line may be assumed to be		
6 feet span	28 tons	14 tons
12 "	34 "	22 "
20 "	46 "	35 "
40 "	90 "	60 "
60 "	107 "	78 "
100 "	160 "	110 "
150 "	213 "	135 "
and the maximum load on a single pair of wheels	14 "	7 "
Sleepers—		
Standard length	9 ft. 11 ins.	6 ft. 0 ins.
" breadth	10 "	8 "
" depth	5 "	4 "
Rails—Standard rail—weight per yard in steel . . .	62 lbs.	41¼ lbs.
Stations, &c.—		
Standard height above rail level for passenger platforms at important stations	3 ft. 0 ins.	1 ft. 3 ins.[2]
Do. Do. for carriage and horse landing platform .	4 " 0 "	
Do. Do. for goods platforms, and for carriage and horse landing platforms on metre-gauge lines . .	3 " 6 "	2 " 3 "

[1] The lengths of platform and siding apply only when ruling gradient is flatter than $\frac{1}{150}$; when the ruling gradient is steeper they may be proportionately reduced.

[2] At very unimportant stations the platform may be omitted altogether, its site being marked by slabs of stone about 3 inches above rail level.

to the total earnings, excluding expenses connected with the steamboat traffic, is (Item No. 10) 12½ per cent. higher upon the narrow-gauge railways.

Coaching Traffic. Items Nos. 11 *to* 24 *inclusive.*—Before dealing with statistics relating to the coaching and goods traffic, it may be convenient to give the following main dimensions and particulars of the vehicles for both gauges, as prescribed in the Government Regulations.[1]

INDIAN RAILWAYS.—LEADING DIMENSIONS and PARTICULARS of COACHING and GOODS VEHICLES.

Particulars.	Railways of 5 feet 6 inches Gauge.	Railways of Metre Gauge.
(1) *Maxima and Minima Dimensions to be strictly observed.*		
Loading gauge for goods—		
Maximum width	10 ft. 6 ins.	8 ft. 6 ins.
" height at centre	13 " 6 "	11 " 0 "
" " sides	11 " 6 "	9 " 6 "
Rolling stock—		
Maximum rigid wheel-base for passenger vehicles	16 " 0 "	10 " 0 "
" " " for goods vehicles	12 " 0 "	10 " 0 "
" gross load on a pair of engine-wheels	12 tons	7 tons
" " " carriage or wagon wheels	8 "	4½ "
(2) *Standard Dimensions, &c., to be observed as far as possible.*[2]	Ft. Ins.	Ft. Ins.
Distance apart of buffers, centre to centre	6 5	
Mean height above rail level for centre of buffers	3 6	1 10
Diameter of wheels for all passenger and goods vehicles	3 7	2 0
Passenger vehicles—		
Length over buffers	28 0	21 6
" outside body	24 0	18 0
Wheel-base	14 0	10 0
Inside in the clear—		
Length	23 6	17 6
Width	8 6	6 6
Height at centre	7 9	6 9
" at sides	6 9	6 3
Goods vehicles—		
Length over buffers	22 0	18 0
" outside body	18 6	14 6
Wheel-base	11 0	8 0
Inside in the clear—		
Length	18 0	14 0
Width	8 6	6 6
Height at centre for covered wagons	8 0	6 6
" at sides " "	7 0	6 0

[1] Administration Report upon Railways in India for 1882–83. Appendix K, p. clv. *et seq.*

[2] In the case of metre-gauge railways it is stated that the standard dimensions do not apply to cotton wagons nor to covered goods wagons of military type.

metre gauge, and that the difficulties encountered in constructing them contributed to swelling their cost to a degree which did not occur in the case of the latter. The Author will, therefore, in the concluding portion of this Paper, touch briefly upon some of the salient points connected with the working statistics of lines upon both of these gauges.

The Administration Reports for 1886–87 contain detailed information, connected with the working statistics, during the year 1886, of eight of the principal broad-gauge railways, aggregating in length nearly 7,648 miles out of the total of 7,987¾ miles open on that gauge; and of twelve of the principal metre-gauge railways, aggregating in length 4,421 miles out of the 5,117 miles of line on that gauge open for traffic.

From that information Table IV in the Appendix has been compiled, which exhibits the mean, maximum, and minimum values of the most important items connected with working statistics of those railways, both of the broad and narrow gauges, together with the differences between these mean values, and the gauge of the lines on which the higher mean value occurs.

The remainder of the Paper refers concisely to the results shown by Table IV.

General Results. Items Nos. 1 *to* 10 *inclusive.*—Notwithstanding the higher capital outlay per mile, which, as shown by Item No. 1, has, upon the railways of 5 feet 6 inches gauge, been 168 per cent. more than upon the metre-gauge lines, the average net return is 1·262 per cent. higher upon the broad-gauge railways.

This favourable result is due not only to the "Total earnings per mile open per week" (Item No. 3) being more than 168 per cent. higher, and the "Total earnings per train-mile" (Item No. 6) being more than 41 per cent. higher upon lines of the broad-gauge; but also to the fact that the working expenses, both per mile per week, and per train-mile, do not increase in the same proportion; the corresponding figures (Items Nos. 4 and 7) being 11·3 per cent. and 11·5 per cent. only. The margins of profit or net earnings (Items Nos. 5 and 8) are thus largely in favour of railways of the 5 feet 6 inches gauge.

The cost per 1,000 gross ton-miles moved (Item No. 9) is more than 50 per cent. higher upon railways of the metre, than upon those of the standard gauge; while the mean total weight of the traffic, passing over each mile of the railways of the latter gauge, is (Item No. 9*a*) nearly three times as much as that conveyed over each mile of the metre-gauge lines.

From the foregoing figures, the percentage of working expenses

to the total earnings, excluding expenses connected with the steamboat traffic, is (Item No. 10) 12½ per cent. higher upon the narrow-gauge railways.

Coaching Traffic. Items Nos. 11 *to* 24 *inclusive.*—Before dealing with statistics relating to the coaching and goods traffic, it may be convenient to give the following main dimensions and particulars of the vehicles for both gauges, as prescribed in the Government Regulations.[1]

INDIAN RAILWAYS.—LEADING DIMENSIONS and PARTICULARS of COACHING and GOODS VEHICLES.

Particulars.	Railways of 5 feet 6 inches Gauge.	Railways of Metre Gauge.
(1) *Maxima and Minima Dimensions to be strictly observed.*		
Loading gauge for goods—		
Maximum width	10 ft. 6 ins.	8 ft. 6 ins.
„ height at centre	13 „ 6 „	11 „ 0 „
„ „ sides	11 „ 6 „	9 „ 6 „
Rolling stock—		
Maximum rigid wheel-base for passenger vehicles	16 „ 0 „	10 „ 0 „
„ „ „ for goods vehicles	12 „ 0 „	10 „ 0 „
„ gross load on a pair of engine-wheels	12 tons	7 tons
„ „ „ carriage or wagon wheels	8 „	4½ „
(2) *Standard Dimensions, &c., to be observed as far as possible.*[2]	Ft. Ins.	Ft. Ins.
Distance apart of buffers, centre to centre	6 5	
Mean height above rail level for centre of buffers	3 6	1 10
Diameter of wheels for all passenger and goods vehicles	3 7	2 0
Passenger vehicles—		
Length over buffers	28 0	21 6
„ outside body	24 0	18 0
Wheel-base	14 0	10 0
Inside in the clear—		
Length	23 6	17 6
Width	8 6	6 6
Height at centre	7 9	6 9
„ at sides	6 9	6 3
Goods vehicles—		
Length over buffers	22 0	18 0
„ outside body	18 6	14 6
Wheel-base	11 0	8 0
Inside in the clear—		
Length	18 0	14 0
Width	8 6	6 6
Height at centre for covered wagons	8 0	6 6
„ at sides „ „	7 0	6 0

[1] Administration Report upon Railways in India for 1882–83. Appendix K, p. clv. *et seq.*

[2] In the case of metre-gauge railways it is stated that the standard dimensions do not apply to cotton wagons nor to covered goods wagons of military type.

Notwithstanding the average sums received both for carrying a passenger unit of all classes 1 mile, and for other coaching traffic per ton-mile, being, the former slightly, and the latter considerably higher (Items Nos. 12 and 13) upon the metre-gauge railways, the coaching receipts per train-mile are (Item No. 11) nearly 10 per cent. in favour of lines of the broad gauge; and this result would appear to be due to the trains on the latter gauge, on the average, carrying a somewhat larger number of passengers, and a much greater weight of other coaching traffic. (Items Nos. 14 and 15).

The average number of vehicles in a coaching train is appreciably higher upon the metre-gauge railways (Item No. 16). The freight weight of a coaching train, from the larger number of passengers and greater weight of other traffic carried, is slightly higher upon the lines of 5 feet 6 inches gauge (Item No. 17); while the average dead and total weights of a coaching train are each (Items Nos. 18 and 19) about 50 per cent. higher upon lines of that gauge, the percentage of freight to dead-weight is 2·13 per cent. (Item No. 20) in favour of the metre-gauge railways. The somewhat unfavourable position occupied by the broad-gauge lines in this respect is possibly due to the larger proportion of passengers travelling in carriages of the higher classes carried on them, who do not, it is presumed from English railway experience, fill the carriages so well as those travelling by vehicles of the lowest class.[1]

[1] The following statement gives the average sums received for carrying one passenger-unit 1 mile, the total number of passengers of each class carried, and the proportions of those of each class to the total number upon the railways, the statistics of which are given in Table III.

Class.	Railways of 5 feet 6 inches Gauge.			Railways of Metre Gauge.		
	Average Sums received for carrying one passenger-unit 1 mile.	Number of Passengers carried.	Percentages of Total Number.	Average Sums received for carrying one passenger-unit 1 mile.	Number of Passengers carried.	Percentages of Total Number.
	Pies.			Pies.		
1st	12·25	305,825	0·51	15·23	66,275	0·23
2nd	4·7	1,763,001	2·92	5·74	198,362	0·82
3rd	3·23	2,795,635	4·64	4·86	268,183	1·16
4th	2·3	55,427,854	91·93	2·37	24,273,314	97·78
	Totals	60,292,315	100·00	..	24,824,134	99·99

Notwithstanding the excess in total weight, and the larger proportion of dead to paying weight, in the coaching trains of railways on the 5 feet 6 inches gauge, the financial results of the coaching traffic are wholly and very appreciably in favour of lines on that gauge.

The cost of hauling, not only a passenger, but even the much heavier trains, is less (Items Nos. 22 and 21), and the margins of profit or net earnings on these operations are (Items Nos. 24 and 23) consequently larger upon lines of the broad gauge.

Goods Traffic Items, Nos. 25 *to* 39 *inclusive.*—A similar examination into the statistics of the goods traffic shows the greatly increased economy of the broad gauge, in dealing with traffic of that nature.

The receipts per train-mile are (Item No. 25) 76 per cent. higher upon railways of the 5 feet 6 inches gauge, although the average rates per ton (Item No. 26) are more than 10 per cent. higher upon lines of the narrow gauge.

The average number of vehicles in a train is greater (Item No. 27), and the average loads carried by each (Items Nos. 28 and 29) are much heavier upon lines of the broad gauge.

The average freight, dead, and total weights of goods trains are respectively (Items Nos. 30, 31, and 32), 93 per cent., 94 per cent., and 94 per cent. greater upon lines of the 5 feet 6 inches gauge.

The practical results of the working of the goods traffic are given in items Nos. 33 and 34, where it is shown that the proportion of paying freight upon the capacity hauled is 1·158 per cent. in favour of the broad-gauge lines, while the proportion of freight-weight to dead-weight is practically within a small fraction the same upon railways of both gauges. Thus the great anticipated economy in both these respects, so often and so strongly insisted upon by advocates of narrow-gauge railways generally, has not been realized in practice, so far, at any rate, as Indian railways are concerned.

Notwithstanding the average weight of the goods trains on the broad-gauge lines being, as stated above, nearly double that of the corresponding trains on the metre-gauge lines, the increased cost of hauling them is (Item No. 35), only 27 per cent.; while, if the cost per ton-mile be taken as the basis of comparison, the balance of advantage is (Item No. 36) nearly 53·6 per cent. in favour of increased economy upon railways of the 5 feet 6 inches gauge; and even taking into account interest upon capital expended upon construction of the lines (Item No. 37), it is still nearly 33 per cent.

From what has been already shown in respect to the goods

traffic, it is evident that the remaining items (Nos. 38 and 39), namely, the average profits per train-mile and per ton-mile, are greatly in favour of lines upon the broad gauge.

Percentages of Earnings from various sources to Total Earnings. Items 40 *to* 43 *inclusive.*—Upon this subject it is only necessary to remark that the railways of 5 feet 6 inches gauge, forming the main routes of the country, and connecting the large cities and wheat-producing districts of the interior with the principal seaports of Calcutta, Bombay, and Kurrachee, appear to have secured a larger proportion of goods traffic, on which the profits seem to be higher than on passenger traffic, than the metre-gauge railways.

Percentages of Working Expenses upon Total Earnings. Items 44 *to* 51 *inclusive.*—In each of the items included under this heading, the metre-gauge railways are in excess of the lines of 5 feet 6 inches gauge, the total excess, including steam-boat expenses, being 12·394 per cent.

Cost and Particulars of Maintenance of Way, Works, and Stations. Items Nos. 52 *to* 55 *inclusive.*—The mean age of the railways of 5 feet 6 inches gauge, included in Table IV, is (Item No. 52) more than three times that of the metre-gauge railways with which they are compared.

In instituting any comparison between the cost of maintenance of broad and of narrow-gauge railways based, as items Nos. 53, 53*a*, and 53*b* are, upon the cost per mile, either of railway or of track including sidings, the relative average annual weight of traffic, conveyed over each mile of the railways compared, must not be overlooked; this, as shown by item No. 9*a*, is three times greater upon the lines of 5 feet 6 inches gauge than upon those of the metre gauge.

As regards items Nos. 53 and 53*a*, giving respectively the comparative cost of maintenance of way, works, and stations per mile of railway, and per mile of track including sidings, the weight of the traffic passing over each mile forms an important factor; while item No. 53*b*, giving the cost of maintenance of permanent way alone per mile of track, including sidings, will be almost wholly dependent upon it.

Again, in considering item No. 54, giving the average cost of maintenance per train-mile, which is 13 per cent. higher upon the broad than on the narrow-gauge lines, the relative weights of the trains on both gauges (Items Nos. 19 and 32) cannot with justice be omitted.

Viewed thus, although the cost of maintenance, both per mile of line, per mile of track, and per train-mile, is higher upon the 5 feet

6 inches gauge than upon the metre-gauge railways; yet the excess in cost, not being even approximately in proportion to the excess in weight of the traffic passing over each mile, and to the increased weight of the trains, the balance of economy is largely in favour of the broad-gauge railways.

Basing the comparative average cost of maintenance upon the expenditure per 1,000 gross ton-miles (Item No. 55), which, it is submitted, when, as in the present case, the other conditions vary so greatly, forms the only proper stand-point from which to examine the question, the cost is no less than 58 per cent. higher upon the narrow than upon the broad-gauge lines. Inasmuch as the bulk of the expenditure upon maintenance is incurred in the cost of repairs and renewals of the permanent way, the average cost of this to the total expenditure for maintenance being, per 1,000 gross ton-miles, 51 per cent. on the broad and 54 per cent. upon the narrow-gauge lines, the result, as shown in item No. 55, seems to indicate that the type of permanent way adopted for the metre-gauge lines is not so well suited, even for their limited traffic, as that adopted for the heavier traffic on the lines of 5 feet 6 inches gauge; and that an increase in the weight of the rails, in the scantlings of the sleepers, and in the amount of ballast used on lines of the narrow gauge, would be attended with beneficial results. This seems to have been recognized by the Government in the case of the Rajputana-Malwa railway, the heaviest worked of the metre-gauge lines, on which (Table No. I) all renewals are to be made with rails of increased weight.

Cost and Particulars of Locomotive Expenses. Items Nos. 55a to 58d inclusive.—In item No. 55*a* it is shown that a slightly higher daily mileage is obtained from the engines on the broad-gauge lines.

The average locomotive expenses, both per train-mile and engine-mile (Items Nos. 56 and 57), are, taking the weights of the trains into account, higher upon the broad than upon the narrow-gauge lines; although the comparative increase in cost is not in so high a ratio as the comparative increase in the weights of the trains drawn. On the other hand, taking the cost per 1,000 gross ton-miles as the basis of comparison, which the Author considers to be the only just and proper one between railways of such widely different character and capacity for dealing with the traffic, the balance of economy is (Item No. 58) more than 69 per cent. in favour of the broad-gauge lines.

The cost of fuel is, of course, an important factor in dealing with the question of locomotive expenses; and this, on the average

(Item No. 58*a*), is considerably higher on railways of the metre, than on those of the 5 feet 6 inches, gauge. Eliminating it, therefore, from the lines of both gauges, the average locomotive expenses per 1,000 gross ton-miles shows (Item 58*d*) an economy of nearly 28 per cent. in favour of the broad-gauge lines.

The consumption of fuel per train-mile (Item No. 58*b*) is higher upon the broad-gauge lines; although here again the increase in consumption is not in the same proportion as the increased weight of the trains on railways of that gauge; on the other hand, the average consumption per 1,000 gross ton-miles (Item 58*c*) shows an economy of more than 26 per cent. in favour of the broad gauge.

Amount and Particulars of Carriage and Wagon Expenses. Items Nos. 59 *to* 60*b inclusive.*—The carriage and wagon expenses, both per total train-mile and per 1,000 vehicle-miles run by home vehicles (Items Nos. 59 and 60) are in point of economy in favour of the metre gauge; the excess in expenditure upon the broad-gauge lines in the latter item being rather more than 50 per cent.

It is to be regretted that, in the Administration Reports, the carriage and wagon expenses are not calculated per 1,000 gross ton-miles, and that they contain no data by which this can be done. The information (Item 28) where the average load of the goods vehicles, both loaded and empty, on the lines of both gauges, is given, enables such a comparison to be made on the basis of the cost per ton of paying load per 1,000 vehicle-miles, as far as the goods traffic is concerned.

The average loads of the goods vehicles, both loaded and empty, on both gauges, is there stated to be 4·719 tons and 2·74 tons, upon the standard and the metre-gauge lines respectively. Combining this with item No. 60, the following result is arrived at:—

For goods traffic only, per 1,000 vehicle-miles, 4,719 tons of paying load or freight are drawn on railways of 5 feet 6 inches gauge for an average sum of Rs. 9,149; and 2,740 tons of paying load or freight are drawn on railways of the metre gauge for an average sum of Rs. 6,044. The average cost per 1,000 ton-miles of paying load is thus nearly Rs. 1·94 upon the broad, and a little over Rs. 2·20 upon the narrow-gauge lines, again showing a decided economy in favour of lines upon the broad gauge. From items Nos. 60*a* and 60*b* it will be observed that the average annual mileage, by both coaching and goods vehicles, is much larger upon the broad-gauge railways.

Amount and Particulars of Traffic Expenses. Items Nos. 61 *to* 64 *inclusive.*—The traffic expenses per train-mile are somewhat higher (Item No. 61) upon railways of the 5 feet 6 inches gauge than on

those of the metre gauge. The distance of the stations apart is somewhat less on the former than on the latter lines. The train-mileage per mean mile of railway worked is 76 per cent. per annum more upon lines of the broad gauge; upon which, also, the passenger and mixed trains travel at a higher speed, the contrary being the case as regards the goods trains.

General Charges, Item No. 65.—Finally, the average amount of general charges per train-mile is much higher upon railways of the metre gauge than upon those of the 5 feet 6 inches gauge.

The limits within which it has been necessary to compress this Paper, have compelled the Author to omit all reference to projected railways in India, as well as much interesting matter connected with the particulars both of working and of constructing the open lines. He has, however, endeavoured to touch, in many cases very concisely, upon the more important figures connected with these latter subjects, which have been abstracted without bias from the most authentic sources; these are the Administration Reports prepared in India by the Director General of Indian Railways for presentation to the Houses of Parliament.

The figures given have been carefully checked, and the Author trusts that they may prove to be correct. He has, as far as possible, endeavoured to avoid the expression of any opinions of his own, unless they were amply borne out, in his judgment, by the facts and figures adduced, if not, indeed, almost logical conclusions from them. He is sensible of many shortcomings in the way in which his task has been performed, and his excuse for undertaking it must be the deep interest which, from his past connection with India, he feels in all matters relating to the welfare of that Empire, coupled with the fact that he has been led to some extent, by his recent professional practice, to inquire into matters connected with the relative cost both of construction and of working of railways upon comparatively broad and narrow gauges.

The Paper is accompanied by a diagram, from which the Fig. in the text has been engraved.

APPEN

TABLE I.—STATEMENT of INDIAN RAILWAYS CONSTRUCTED

No.	Name of Railway.	Gauge.	Length sanctioned.	Length opened.	Length laid with double line.	Average Cost per mile open on 31st Dec., 1886.	Net Earnings during 1886 on Capital.
		Feet Ins.	Miles.	Miles.	Miles.	Rupees.	Per cent.
I.	East Indian . . .	5 6	1,519¼	1,519¼	474¼	210,686	8·40
II.	Rajputana-Malwa .	3 3⅜	1,414¼	1,414¼	1¼	76,848	7·19
III.	Pátri	5 6	22½	22½	..	35,929	..
IV.	Sindia	5 6	74¾	74¾	..	122,896	..
V.	Dhond-Manmád .	5 6	145½	145½	..	74,893	..
VI.	Southern Mahratta.	3 3⅜	763¾	597½	..	66,505	1·82
VII.	Mysore	3 3⅜	296¼	139¾	..	44,997	2·84
VIII.	Indian Midland. .	5 6	606	42	..	67,566	..
IX.	North Western . .	5 6	1,839¼	1,839¼	2¼	157,682 [1]	4·09
	Carried forward .		6,681½	5,794¾	477¾		

[1] Cost of Punjab Northern Railway per mile up to opening on 30th June, 1884, per mile was Rs. 119,337. Cost of Sind, Punjab and Delhi line up

DIX.

and in PROGRESS on 31st MARCH, 1887.

Remarks.
Earthwork and bridges, generally for a double line, except two short branches, superstructure of iron girder bridges generally for single line only. Permanent-way rails vary from 74 lbs. to 82 lbs. per lineal yard laid on wooden or iron-plate sleepers. Length laid with steel rails on 31st December, 1886, 739·01 miles.
Length of 3 miles, viz., East Indian Railway to limit of Agra Cantonment, laid on 5 feet 6 inches gauge. Constructed for single line, land taken up for double line. Rails originally 36 lbs. per yard, but these have nearly all been replaced by steel rails of 41¼ lbs.; for future renewals 50-lb. rails are to be used. Sleepers, originally creosoted pine, are perishing, and are being renewed with deodar. On Rajputana section the chief works are the Bangunga, Shallas, Dhund, Amanishah, and Jumna bridges, and descent of Aravalli range. On Holkar Railway the chief works are the ascent of the Vindhya range and bridge over Nerbudda. Rewári-Ferozepore and Fázilka branch line, 290¾ miles, presented no difficulties, and 201¾ miles of this section are unballasted and unfenced. Steel rails and Denham-Olpherts iron sleepers are used on the Fázilka branch.
Line made and worked by the Bombay, Baroda, and Central India Railway Co. The rails, flat-footed, weigh 48 lbs. per yard.
Worked by East Indian Railway. Rails 60 lbs. per yard, on deodar transverse sleepers. Principal work, Chumbul River bridge.
Single line, double-headed steel rails, 70 lbs. per yard, laid on pot sleepers weighing 94 lbs. each. The line will shortly be fenced; it is worked by Great Indian Peninsula Railway.
Permanent way of State Railway, metre-gauge type. The following large bridges are finished:—Bhima, fourteen spans of 150 feet; Don, eight spans of 100 feet; Krishna, twenty-one spans of 150 feet; Malprabha, twelve spans of 100 feet; Tungabhadra, thirty-eight spans of 60 feet; Burra Nalla, ten spans of 60 feet; Wardha, fifteen spans of 100 feet. The Ghât incline for 3½ miles from Portuguese frontier will up to formation be for a double line, all the rest single line. Maximum grade on ghât $\frac{1}{40}$, on rest of line $\frac{1}{100}$.
No works of special difficulty. Formation 14 feet wide; rails 41¼ lbs. per yard, spiked to creosoted pine and teak sleepers. Maximum gradient $\frac{1}{100}$. Sharpest curve, 3,000 feet radius.
No engineering difficulties on open line. Single line, formation 20 feet wide, rails 75 lbs. per yard double-headed, laid on Denham-Olpherts sleepers. Line to be fenced.
Comprises Sind, Punjab, and Delhi, Punjab Northern, Indus Valley, Eastern section Sind-Sagar, and Southern section of Sind-Pishin Railways. On Delhi Railway the earthwork for 26 miles is for a double line; steel rails,

was Rs. 162,847. Cost of Indus Valley line up to opening on 30th June, 1883, to 31st December, 1870, per mile was Rs. 148,952.

TABLE 1.—STATEMENT of INDIAN RAILWAYS CONSTRUCTED

No.	Name of Railway.	Gauge.	Length sanctioned.	Length opened.	Length laid with double line.	Average cost per mile open on 31st Dec., 1886.	Net Earnings during 1886 on Capital.
		Feet Ins.	Miles.	Miles.	Miles.	Rupees.	Per cent.
	Brought forward .		6,681½	5,794¾	477¾		
IX.	North Western (*continued*).						
X.	Sind-Sagar (western section).	5 6	341	120	..	..	..
XI.	Sind-Pishin . . .	5 6	219¾	99	..	..	..
XII.	Eastern Bengal . .	5 6	237	234¾	23¼	202,946	3·96
	Carried forward .		7,479¼	6,248½	501		

and in PROGRESS on 31st MARCH, 1887.—*continued.*

Remarks.
of 68 lbs. per yard, bull-headed, are used partly on wooden and partly on pot sleepers. Principal works, bridges over Beas, Sutlej, Markunda, Guggur Tangri, and Jumna. On Punjab northern section the rails are of iron, 60 lbs. flat-footed, steel 62 lbs. flat-footed, and steel double-headed 75 lbs. per yard, all laid on wooden sleepers. Principal works are bridges over Ravi, Chenab, Jhelum, Soane, Indus (Attock), and Haro; the passage through the Salt Range, and tunnels at Margala Pass and Indus approach. Sind-Sagar section—partly 75 lbs. steel rails, and partly old iron rails 60 lbs. per yard. Punjab section—iron rails of 68 lbs. and 60 lbs. per yard are being replaced by steel rails of 68 lbs. and 62 lbs. per yard; length of 28 miles done. Sind section, Khánpur to Kotri; rails of iron 60 lbs. and steel 62 lbs. per yard, on wooden sleepers. Principal works cutting through Laki Hills and Indus (Sukkur) Bridge (in progress). Kotri to Kurrachee, earthwork for single line, masonry of bridges for double line; rails 65 lbs. double-headed laid on creosoted pine and babul sleepers. Sind-Pishin—permanent-way of various types; rails flat-footed 60 lbs. and 62 lbs. per yard, and double-headed 68 lbs. to 84 lbs. Chief works, Nari and Kambari bridges. On lower section of Sind-Pishin, E. I. Railway, 75 lbs. steel, on Denham-Olpherts sleepers; E. I. Railway, 80 lbs. steel, on wooden sleepers. Sind, Punjab and Delhi Railway, 68 lbs. iron rails on wooden sleepers; and Sind-Pishin State Railway, 75 lbs. steel rails, Denham-Olpherts sleepers are used; ruling gradients $\frac{1}{23}$ and $\frac{1}{26}$, minimum curves 800 feet radius.
Worked by North Western Railway. Earthwork and bridges light throughout, excepting Jhelum Bridge. Rails, steel, 75 lbs. per yard; seven-eighths laid with steel sleepers, and rest with wooden sleepers. On main line ruling gradient $\frac{1}{200}$, on Khewra branch $\frac{3}{4}$ mile each of $\frac{1}{33}$ and $\frac{1}{60}$, and $\frac{1}{2}$ mile $\frac{1}{110}$. Sharpest curve on main line 1° and on branch lines 4° Opened 21st January, 1887.
Worked by North Western Railway; 40 miles laid with double-headed rails, 75 lbs. per yard, on Denham-Olpherts sleepers; rest of line laid with flat-footed steel rails, 75 lbs. per yard, on steel trough sleepers. Single line throughout. Steepest gradient $\frac{1}{13}$. Works very heavy. High banks and deep cuttings are the rule for $113\frac{1}{2}$ miles, on which are fourteen tunnels, together 8,000 feet long. On this section are thirty-seven spans of 150 feet, twenty-three spans of 100 feet, and one hundred and five spans of 40 feet, and one bridge of 150 feet span—the "Louise Margaret," spanning the Chappar Rift at a height of 300 feet. On rest of line, between Quetta and Gulistan, the bridging is not so heavy. There are fourteen spans of 40 feet, four of 60 feet, one span of 100 feet, one of 120 feet, and one of 150 feet. Opened partly for goods traffic only 20th March, 1887.
Earthworks and masonry of bridges and viaducts generally for double line; but girders erected for single line only, except between Calcutta and Nalháti, where double line is laid. Rails generally double-headed, 74 lbs. per yard, laid on wooden sleepers, but on short lengths cast-iron pot sleepers are used. The Calcutta to Canning section single track only, masonry of bridges for double line, but girders for single line only except in two instances. On Diamond Harbour branch, 27 miles are laid with steel rails, 64 lbs. per yard, partly on pot and partly on Denham's plate sleepers.

TABLE I.—STATEMENT of INDIAN RAILWAYS CONSTRUCTED

No.	Name of Railway.	Gauge.		Length sanctioned.	Length opened.	Length laid with double line.	Average cost per mile open on 31st Dec., 1886.	Net Earnings during 1886 on Capital.
		Feet	Ins.	Miles.	Miles.	Miles.	Rupees.	Per cent.
	Brought forward .			7,479¼	6,248½	501		
XIII.	Wardha Coal . .	5	6	46½	46½	..	133,539	..
XIV.	Bengal Central . .	5	6	125¼	125¼	..	69,168	..
XV.	Biláspur-Etáwa. .	5	6	37	37	..	120,574	..
XVI.	Bellary-Kistna . .	3	3⅜	278¾	..	..	..	..
XVII.	Cuddapah-Nellore .	3	3⅜	83	..	..	..	..
XVIII.	Nágpur-Bengal . .	5	6	479¼	..	..	..	..
XIX.	Toungoo-Mandalay. Extension-Burma	3	3⅜	225	..	..	..	..
XX.	Patna-Gya	5	6	57¼	57¼	..	73,682	..
XXI.	Cawnpore-Achnera.	3	3⅜	253½	253½	..	44,239	2·38
XXII.	Dildárnagar-Gházipur	5	6	12	12	..	58,588	..
XXIII.	Bareilly-Pilibheet .	3	3⅜	36	36	..	41,865	..
XXIV.	Lucknow - Sitapur - Sihrámau . . .	3	3⅜	124	55½	..	24,974	..
XXV.	Nalháti	4	0	27¼	27¼	..	11,967	..
XXVI.	Tirhoot	3	3⅜	273¼	245¾	..	64,934	2·87
XXVII.	Northern Bengal[1] .	3	3⅜	285¾	285¾	..	87,235	5·59
XXVIII.	Dacca	3	3⅜	86	86	..	75,099	..
XXIX.	Assam-Behar . .	3	3⅜	155½	..	..	..	..
XXX.	Amritsar-Pathánkot	5	6	65	65	..	84,676	..
XXXI.	Nágpur - Chhattísgarh.	3	3⅜	149	149	..	73,339	4·88
	Carried forward .			10,278½	7,730¼	501		

[1] On Kaunia Dharlla branch, 37 miles long, gauge is

and in PROGRESS on 31st MARCH, 1887—*continued.*

Remarks.
Rails 67 lbs. and 68 lbs. per yard laid on creosoted pine, teak and sâl sleepers.
Worked by Eastern Bengal State Railway. Single line, sand ballasted generally; line is fenced throughout. Steel rails, Vignoles' section, 62 lbs. per yard, laid on creosoted pine sleepers.
Constructed for single track only. First-class second-hand East Indian Railway permanent way, laid on sâl sleepers; rails 82 lbs. per yard for three quarters of its length, and 74 lbs. for remainder. Bridging light, earthwork and rock-cutting heavy; ruling gradient $\frac{1}{100}$, sharpest curve 1,432 feet radius.
Ruling gradient $\frac{1}{100}$, for 20 miles through Nulla-Mulla hills. Heavy works, including a tunnel 413 yards long; rest of line easy.
Ruling gradient $\frac{1}{165}$. Country flat, but drainage area large, necessitating high banks and much waterway.
Line in general character will conform to standard Indian railways, 5 feet 6 inches gauge.
Permanent way steel rails, 50 lbs. per yard. Vignoles' section deep fish plates of Bessemer steel laid on teak and pyingado sleepers. No engineering difficulties.
Worked by East Indian Railway; rails 64 lbs. per yard; first 29 miles laid on cart road.
Rails, steel, 40 lbs. and 41¼ lbs. per yard. Single track for 22 miles, borders the cart road. No engineering difficulties except bridge over the Jumna.
Worked by East Indian Railway; unfenced except at stations. Steel rails, 62 lbs. per yard, laid on bearing plates and creosoted pine sleepers.
Steel rails, 41¼ lbs. per yard, on deodar and sâl sleepers; unfenced except for 4½ miles.
No engineering difficulties; only bridge of importance is that over Goomti, at Lucknow. Steel rails, 41¼ lbs. per yard.
Laid on the cart road. Rails, 31 lbs. per yard, except on a small section, where 41¼ lbs. steel rails are used. Sleepers of teak, sâl, and pine.
Easy country. Rails, iron 40 lbs., and steel 41¼ lbs. per yard, on deodar, sâl, Denham-Olpherts, and Denham's sleepers.
Rails, 40 lbs. per yard; sleepers of creosoted pine, sâl, red gum, wrought and cast-iron. Bridging and banks heavy on lower section. On Kaunia Dharlla branch, 2 feet 6 inches gauge, there is no ballast, and the rails are steel, 25 and 30 lbs. per yard, laid on sâl sleepers.
Rails, steel, 41¼ lbs. per yard; work on northern half of line is heavy. Sâl sleepers.
Rails, steel, 41¼ lbs. per yard, on sâl, ironwood, and Denham-Olpherts sleepers. Works are heavy, and bridging considerable as a rule.
Worked by North Western Railway. Steel rails, 62 lbs. per yard; work very light. Steepest gradient $\frac{1}{265}$, sharpest curve 2,300 feet radius.
Rails 40 lbs. per yard on creosoted pine, sâl, and teak sleepers. Line to be handed over to Nágpur-Bengal Railway for conversion into 5 feet 6 inches gauge.

2 feet 6 inches, cost per mile Rs. 21,946.

TABLE I.—STATEMENT of INDIAN RAILWAYS CONSTRUCTED

No.	Name of Railway.	Gauge.		Length sanctioned.	Length opened.	Length laid with double line.	Average cost per mile open on 31st Dec., 1886.	Net Earnings during 1886 on Capital.
		Feet	Ins.	Miles.	Miles.	Miles.	Rupees.	Per cent.
	Brought forward .			10,278½	7,730¼	501		
XXXII.	Burma	3	3⅜	369	327	..	83,286	3·40
XXXIII.	Jorhát	2	0	29	26¾	..	18,573	..
XXXIV.	Cherra Co. Ganj .	2	6	15	7½	..	32,859	..
XXXV.	Madras	5	6	840½	828¾	42½	130,919	2·78
XXXVI.	South Indian . .	3	3⅜	654½	654½	..	67,808	3·15
XXXVII.	Great Indian Peninsula.	5	6	1,288½	1,288¼	323½	202,729	7·80
XXXVIII.	Bombay, Baroda and Central India.	5	6	438½	438½	43¾	196,691	8·56
XXXIX.	Oudh and Rohilkhand.	5	6	735¾	686	..	115,255	3·51
XL.	Darjeeling-Himalayan.	2	0	51	51	..	52,609	..
XLI.	Deoghur. . . .	3	3⅜	4¾	4¾	..	57,420	..
XLII.	Bengal and North Western.	3	3⅜	510¼	376¼	..	58,214	3·96
XLIII.	Tárakeshwar . .	5	6	22¼	22¼	..	77,585	..
XLIV.	Burdwan-Kutwa .	2	6	40	..	..	..	..
XLV.	Rohilkhand-Kumaun	3	3⅜	54½	54½	..	39,268	4·81
XLVI.	Thatôn Duyinzáik .	2	6	8	8	..	..	..
XLVII.	Dibru Sadiya . .	3	3⅜	77½	77½	..	63,370	..
XLVIII.	Pondicherry. . .	3	3⅜	7¾	7¾	..	..	..
	Carried forward .			15,424¾	12,589½	910¾		

and in PROGRESS on 31st MARCH, 1887—*continued.*

Remarks.
Irrawaddy line; works light except bridging, amounting to 8,165 lineal feet; rails 40 lbs. per yard. Sittang line; works light except bridging, amounting to 15,730 lineal feet; steel rails, 41½ lbs. per yard.
Rails, steel, 18 lbs. and 14 lbs. per yard. Most of railway constructed on cart roads. Sharpest curve 300 feet radius, steepest gradient $\frac{1}{100}$.
On open portion; steel rails, 25 lbs. per yard, laid on steel sleepers, are used.
Embankments, except on double line, are for a single line only, but bridges and viaducts are for a double line, except for 25¾ miles. Rails 65 lbs. to 84 lbs. per yard, generally on pot sleepers. On Bangalore branch rails are 57 lbs. per yard on pot sleepers.
Earthwork and bridges generally for single line only, except from Negapatam to Trichinopoly, where bridges are built for double line. On 167 miles rails weigh 68 lbs. per yard, and are laid on pot and wooden sleepers; on 39 miles rails are 35¾ lbs. per yard; on rest of system the rails are 40 lbs. per yard, but are being renewed with 50-lb. bull-headed rails on cast-iron sleepers—a length of 44¾ miles has been completed.
Earthwork, except on double portions, for single line only, but bridges and viaducts are for a double line. Iron rails of 68 lbs. and 84 lbs. per yard are being replaced with steel rails, 69 lbs., 82 lbs., and 86 lbs. per yard. Sleepers wooden, and iron bowls. The doubling of further portions of the line is in progress.
Earthwork generally for single line only, but bridge, piers, and abutments for double line. Rails double-headed, 68 lbs. and 69 lbs. per yard, generally on wooden sleepers, but iron bowls are used for renewals. On Waáhwán extension 60 lbs. rails on iron bowls are used. The Godhra branch, 49¼ miles long, was laid on the Trunk road.
Formation for single line, except for 17 miles, where masonry is for double line. Rails generally 60 lbs. per yard; 435 miles laid on cast-iron oval bowl sleepers, 75 miles on wrought-iron saddle sleepers, and 39 miles on steel saddle sleepers; 136 miles, steel rails, 75 lbs. per yard, are laid on Maclellan and Smith's patent Bessemer-steel sleepers. All renewals are made with steel rails.
Rails, iron 30 lbs. and steel 40 lbs. per yard; mostly laid on cart road. Sharpest curve 70 feet radius, steepest gradient $\frac{1}{28}$.
Undulating country; 36 lbs. steel rails on wooden sleepers; ballasted. Steepest gradient $\frac{1}{80}$, sharpest curve 2,640 feet radius.
Rails, steel, 41¼ lbs. per yard, on wooden sleepers. Country flat, but subject to inundations in places, where therefore earthwork and bridging are heavy. The line, except at stations and near bridges, is unfenced.
Easy work, line fenced and ballasted, and is worked by East Indian Railway.
Not begun; to be built on the cart road.
Permanent way of metre-gauge type on sâl and jungle sleepers; unfenced. Steepest gradient $\frac{1}{70}$ for 175 chains.
Steel rails on steel and wooden sleepers; ballasted and partially fenced.
Steel rails 41¼ lbs. per yard; line unballasted and unfenced generally. The larger portion was made on the Government road.
Iron rails, 40·3 lbs., on wooden sleepers; worked by South Indian Railway.

TABLE I.—STATEMENT OF INDIAN RAILWAYS CONSTRUCTED

No.	Name of Railway.	Gauge.	Length sanctioned.	Length opened.	Length laid with double line.	Average cost per mile open on 31st Dec., 1886.	Net Earnings during 1886 on Capital.
		Feet Ins.	Miles.	Miles.	Miles.	Rupees.	Per cent.
	Brought forward .		15,424¾	12,589½	910¾		
XLIX.	West of India (Portuguese).	3 3⅜	51	41	..	..	..
L.	Berar.	5 6	13	13	..	Khámgaon 60,321 Amráoti 72,444	..
LI.	H. H. The Gaekwar's	2 6	58¾	58¾	..	22,758	..
LII.	H. H. The Nizam's	5 6	509½	204½	..	127,893	2·36
LIII.	Bhopal Itársi . .	5 6	57	57	..	103,828	..
LIV.	H. H. The Gaekwar's Mehsána-Vadnagar	3 3⅜	21	21	..	..	..
LV.	Bhávnagar-Gondal .	3 3⅜	193¼	193¼	..	49,138	4·25
LVI.	Jodhpore . . .	3 3⅜	123¾	123¾	..	17,271	..
LVII.	Rájpura-Patiála .	5 6	16	16	..	81,346	..
LVIII.	Wadhwán-Morvi .	2 6	68	68	..	13,503	..
LIX.	Junagarh-Veráwal .	3 3⅜	66½	..	..	..	..
	Grand total miles [1]	..	16,602½	13,385¾	910¾	..	..

[1] These totals do not exactly correspond with those stated in the body of the

and in PROGRESS on 31st MARCH, 1887.

Remarks.
Opened 17th January, 1887. First 38 miles ruling gradient $\frac{1}{100}$; for single line as regards earthwork and iron superstructure, but for double line as regards all bridges and culverts; rest of line is for a double line. Maximum gradient $\frac{1}{40}$. On Ghâts there are twelve tunnels and heavy masonry, and work nearly equals that on Bhore Ghât of G. I. P. Railway. Rails, 62 lbs. per yard, steel, on creosoted pine, teak, and sál sleepers.
Worked by G. I. P. Railway. Khámgaon line, rails 60 lbs., on bowl sleepers, and on Amráoti line, rails 68 lbs. per yard.
Very easy work. Rails 30 lbs. per yard, on wooden sleepers; formation 10 feet wide.
Permanent way on 87 miles obtained from South Indian Railway; rails 68 lbs. on bowl sleepers; 6 miles are of steel rails, Vignoles' section, 66¼ lbs. per yard on Bessemer steel sleepers; 87 miles are of steel rails, 66¼ lbs. per yard, laid on steel "pea-pod" sleepers; and rest of line is laid with 60-lb. rails on creosoted pine and jungle wood sleepers.
Rails 62 lbs. per yard, steel laid on steel pine and other sleepers; most of the line is unfenced.
Steel rails 41¼ lbs. per yard, and transverse steel-trough sleepers. The country presented no difficulties.
Steel rails 41¼ lbs. per yard, on half-round pine sleepers.
Works very light. Unfenced; rails, iron 36 lbs. per yard, and steel 36 lbs. per yard, laid respectively on wooden and steel sleepers.
Country traversed eminently favourable, the line is practically a surface one. Steel rails 68 lbs. per yard on deodar sleepers. Worked by North Western Railway.
Line laid on bridged and metalled road for 24 miles, and for remainder of its length on unbridged and unmetalled road. Rails of steel 19 lbs. per yard, laid on patent steel sleepers.
Ruling gradient is $\frac{1}{130}$. Rails to be of steel 41¼ lbs. per yard, laid on jungle wood sleepers.

Paper, but the figures are those given in the Administration Report.

TABLE II.—STATEMENT OF THE COST AND PARTICULARS

Railway.	Name of Bridge.	No. of Spans.	Span in Clear.	Length of Bridge.	Depth of Foundation below Low Water.	Height from Low-water Level to under-side of Girders.
Gauge 5 feet 6 inches:			Feet.	Feet.	Feet.	Feet.
East Indian	Soane	28	150	4,726	32	35·6
„ „	Jumna (Allahabad)	17	14 of 200 3 of 30	3,073 162	Average 42	60·0
„ „	„ (Delhi) .	12	211·50	2,640	7 to 39	23·50
	"Jubilee" over the Hooghly.	1 1 1	523·92 106·50 523·67	1,213·25	98·50	55·0
North-Western.	Sutlej (Phillour)	46	99	5,193	40 to 50	16·6
„	Beas	33	99	3,820	43 to 70	20
„	Jumna (Saharanpore).	26	99	2,663·50	42	19
„	Kaisir-i-Hind over the Sutlej at Ferozepore.	27	144·50	4,293	78	26
„	Ravi (Lahore) .	33	93·33	3,217	75	20
„	Alexandra over the Chenab at Wazirabad.	64	135	9,088	75	20
„	Jhelum . . .	50	93·33	4,875	75	20
	Carried forward			44,963·75		

OF SOME OF THE LARGE RAILWAY BRIDGES IN INDIA.

Cost of Protective Works.	Total Cost of Bridge including Protective Works.	Cost per Lin. Foot excluding Protective Works where given.	Remarks.
Rs.	Rs.		
..	3,300,000	698	For double line, with footway 5 feet 8 inches wide between girders. Cost includes some special items not separately detailed. No information as to cost of protective works.
..	4,446,300	1,374	Carries also roadway below rails. Substructure for double line, girders for single line only. Cost includes some special items not separately detailed. No information as to cost of protective works.
..	1,660,355	629	Carries also roadway below rails. Cost includes some special items not separately detailed. No information as to cost of protective works.
None	3,440,424	2,836	(Minutes of Proceedings, Inst. C.E., vol. xcii. p. 73.) Double line. Cost apparently includes that of approach viaducts, the length of which is omitted from the length of bridge.
254,000	3,360,076	598	Cost approximate only. The contract rate was Rs. 428 per lineal foot. Twelve spans have been removed since bridge was built. The cost per lineal foot is calculated for present length of bridge. The cost for protective works includes expenditure to 1874, since which date a large expenditure has been incurred.
300,000	2,590,166	600	The contract rate was Rs. 428 per lineal foot. The figures for the cost of this bridge are approximate only.
200,000	1,534,600	501	The contract rate was Rs. 428 per lineal foot. The cost is approximate only.
789,924	3,773,353	695	This bridge carries a roadway also above the railway.
150,472	1,919,220	550	(Minutes of Proceedings Inst. C.E., vol. liv., p. 61.) Cost includes some special items not separately detailed. Carries also a footpath below rails.
760,237	5,003,377	467	(Minutes of Proceedings Inst. C.E., vol. liv. p. 71.)
64,000	1,551,498	305	(Minutes of Proceedings Inst. C.E., vol. liv. p. 94.) Cost includes some special items not separately detailed. Carries also a footpath below rails.
2,518,633	32,579,369		

TABLE II.—STATEMENT OF THE COST AND PARTICULARS

Railway.	Name of Bridge.	No. of Spans.	Span in Clear.	Length of Bridge.	Depth of Foundation below Low Water.	Height from Low-water Level to underside of Girders.
			Feet.	Feet.	Feet.	Feet.
	Brought forward			44,963·75		
Gauge 5 feet 6 inches—cont. North-Western.	Attock on the Indus.	5	2 of 308·40; 3 of 257	1,655	..	111
"	Empress, over Sutlej at Adamwahan	16	250	4,210	103	28·75
Sind Sagar	Victoria, over Jhelum at Chucknizam.	17	150	2,720	82	24
Eastern Bengal.	Gorai	7; 9½	185; 46·25	1,744	78 to 96; 25	51; 46·50
Madras .	Cauvery . . .	22	64	1,540	14	33
" .	Cheyer . . .	50	64	3,500	100	14
" .	Tungabhadra .	58	64	4,060	14	34
" .	Hagari . . .	34	64	2,380	62	16
Great Indian Peninsula.	Kistna . . .	36	100	3,855	Average 9	48·67
"	Taptee . . .	33	28 of 59; 5 of 138	2,556	Average 15·96	60·33
"	Nerbudda. . .	11	5 of 137; 6 arches of 40	1,052	4·60	81·33
Bombay, Baroda and Central India.	" . .	25	183·50	4,687·50	Average 76	48·50
" "	Taptee . . .	30	60	1,875	Average 20	50·50
Oudh and Rohilkhand	Saie (Jaunpur) .	18	53	1,192	28 to 41	44·75
"	Gomtee (Jaunpur)	16	82	1,472	45 to 50	44·17
"	Gurrah (Shahjahanpur).	18	60	1,309	70 to 80	17·49
"	Ramgunga (Bareilly) . . .	34	56	2,260	85	25·77
"	Ganges (Rájghat)	35	80	3,040	55	24·39
	Carried forward			90,071·25		

OF SOME OF THE LARGE RAILWAY BRIDGES IN INDIA.—*continued.*

Cost of Protective Works.	Total Cost of Bridge including Protective Works.	Cost per Lin. Foot excluding Protective Works where given.	Remarks.
Rs.	Rs.		
2,518,633	32,579,369		
128,220	3,251,565	1,887	This bridge carries also a military road below the railway.
2,006,246	27,101,690	1,210	(Minutes of Proceedings Inst. C.E., vol. lxv. p. 242.) Cost includes some special items not separately detailed. Carries combined road and railway at same level. Cost of protective works includes material for temporary bridge.
263,254	1,828,362	575	Carries combined road and railway at same level, and also a footway on each side on brackets.
236,235	1,800,000	897	(Minutes of Proceedings Inst. C.E., vol. xxxiv. p. 1.) Cost is approximate only.
..	488,508	317	Cost includes some special items not separately detailed.
..	1,245,464	356	(Minutes of Proceedings Inst. C.E., vol. xxiv. p. 184.)
..	755,756	186	Cost includes some special items not separately detailed.
..	849,728	357	Cost includes some special items not separately detailed.
..	1,273,066	330	Girders for single line, piers for double line.
64,910	1,627,248	611	Double line.
..	669,096	636	Girders for single line, piers for double line.
57,000	3,718,289	781	Cost includes some special items not separately detailed.
..	895,260	477	
438	691,192	579	
2,464	735,090	498	
14,136	392,328	289	
708,904	1,313,067	267	
78,212	796,371	236	
6,078,652	82,011,449		

TABLE II.—STATEMENT OF THE COST AND PARTICULARS

Railway.	Name of Bridge.	No. of Spans.	Span in Clear.	Length of Bridge.	Depth of Foundation below Low Water.	Height from Low-water Level to under-side of Girders
			Feet.	Feet.	Feet.	Feet.
Gauge 5 feet 6 ins.—cont.:	Brought forward			90,071·25		
Oudh and Rohilkhand.	Ganges (Cawnpore)	27	{25 of 100, 2 of 40}	2,830	50 to 65	31·66
,,	,, (Balawali)	11	248·17	2,904	100	39·94
,,	Bangunga . .	14	78·50	1,295	60	13·79
,,	Solani	11	148·75	1,760	60	16·00
Bhopal-Itársi	Nerbudda . . .	14	150	2,240	{Average 4}	65·00
Sindia . .	Chumbal . . .	{12, 2}	{186, 136}	2,714	75	112·50
Total bridges of 5 feet 6 inches gauge . . .				103,814·25		
Metre gauge: Rajputana-Malwa.	Jumna (Agra) .	16	133	2,272	70	31·66
,,	Nerbudda . . .	14	183	2,836	14	80·00
Cawnpore-Achnera.	Jumna (Muttra) .	7	150	1,146	71	27·00
Tirhoot .	Gunduck . . .	8	250	2,176	40 to 90	37·50
Bengal and North-Western.	Rapti	9	150	1,350	86	41·00
Total metre-gauge bridges				9,780		
GRAND TOTAL bridges of 5 feet 6 inches and metre gauge				113,594·25		

OF SOME OF THE LARGE RAILWAY BRIDGES IN INDIA.—*continued.*

Cost of Protective Works.	Total Cost of Bridge including Protective Works.	Cost per Lin. Foot excluding Protective Works where given.	Remarks.
Rs. 6,078,652	Rs. 82,011,449		
158,959	1,740,915	559	Carries also a roadway below the railway.
832,166	2,924,760	721	
75,532	550,564	367	Cost includes some special items not separately detailed.
187,352	1,035,170	482	Cost includes some special items not separately detailed.
..	944,171	421	Carries combined road and railway at the same level. The cost includes some special items not separately detailed.
629,683	3,271,035	973	
7,962,344	92,478,064		
48,776	1,833,877	786	Lattice-girders are designed to carry a carriage-road above the railway. The cost includes some special items not separately detailed.
777	1,873,925	660	Girders designed to carry carriage-road below the railway. The cost includes some special items not separately detailed.
14,194	849,000	728	Cost includes some special items not separately detailed.
47,845	1,324.500	587	Has footway on each side carried by brackets.
549,625	1,373,169	610	
661,217	7,254,471		
8,623,561	99,732,535		

TABLE III.—NAMES, ABBREVIATED NAMES and MILEAGE of INDIAN RAILWAYS

5 feet 6 inches gauge.

Name and abbreviated Name of Railway.	Mean Mileage worked during 1886.
	Miles.
East Indian (E. I.)[1]	1,712·71
North Western (N. W.)	1,863·78
Eastern Bengal (E. B.)[2]	359·00
Madras (M.)	860·38
Great Indian Peninsula (G. I. P.)[3]	1,501·37
Bombay, Baroda, and Central India (B. B. & C. I.)[4]	460·90
Oudh and Rohilkhand (O. & R.)	681·48
His Highness the Nizam's (N.)	208·31
Mean total mileage worked	7,647·93

Notes to railways of 5 feet 6 inches gauge.

[1] Statistics relating to East Indian Railway include State Branches and Tárakeshwar Railway.

[2] Statistics relating to Eastern Bengal Railway include those of Bengal Central Railway generally.

[3] Statistics relating to Great Indian Peninsula Railway, include those of Dhond-Manmád, Khámgaon, Amráoti, and Bhopal Railways. The last is worked but not maintained by the Company.

[4] Statistics relating to the Bombay, Baroda, and Central India Railway include the Pátri branch.

the STATISTICS of which are dealt with in TABLE IV.

Metre gauge.

Name and abbreviated Name of Railway.	Mean Mileage worked during 1886.
	Miles.
Rajputana-Malwa (R. M.)[1]	1,474·49
Southern Mahratta (S. M.)	341·18
Tirhoot (T.)	240·64
Northern Bengal (N. B.)	249·25
Cawnpore-Achnera (C. A.)[2]	253·23
Nágpur-Chhattisgarh (N. C.)	149·00
Burma (B.)	327·00
South Indian (S. I.)[3]	662·00
Bengal and North Western (B. & N. W.)	306·37
Rohilkhand-Kumaun (R. K.)[4]	85·00
Bhávnagar-Gondal (B. G.)	193·15
Mysore (M.)	139·75
Mean total mileage worked	4,421·06

Notes to metre-gauge railways.

[1] Statistics relating to the Rajputana-Malwa Railway include those relating to the Cawnpore-Achnera Railway for the fourth quarter of the year.

[2] Statistics relating to the Cawnpore-Achnera Railway are for the first three quarters of the year only.

[3] Statistics relating to the South-Indian Railway include generally those of Pondicherry Railway.

[4] Statistics for the Rohilkhand-Kumaun Railway include for the second half of the year those relating to the Bareilly-Pilibheet Railway.

TABLE IV.—STATISTICS and PARTICULARS RELATING to the

No.	Heading.		Railways of 5 feet 6 inches Gauge. Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.
	General Results (excluding steamboat service except where otherwise mentioned).				
1	Capital outlay per mile open	Rs.	168,100	210,686 (E. I.)	115,255 (O. & R.)
2	Percentage of net earnings (including steamboat traffic) on capital outlay	,,	5·185	8·56 (B. B. & C. I.)	2·36 (N.)
3	Total earnings per mile open per week	,,	346·50	563·50 (B. B. & C. I.)	144·0 (N.)
4	Total working expenses per mile open per week . .	,,	164·80	247·50 (E. B.)	72·5 (N.)
5	Profit on net earnings per mile open per week . .	,,	181·70	349·0 (E. I.)	71·5 (N.)
6	Total earnings per train-mile	,,	4·28	5·88 (B. B. & C. I.)	3·135 (O. & R.)
7	Total working expenses per train-mile	,,	2·112	2·705 (E. B.)	1·77 (O. & R.)
8	Net earnings per train-mile	,,	2·168	3·435 (B. B. & C. I.)	1·365 (O. & R.)
9	Cost per 1,000 gross ton-miles moved (freight and dead weight)	,,	7·034	9·755 (E. B.)	4·91 (E. I.)
9a	Ton mileage hauled per mean mile worked . .		1,211,429	1,932,162 (E. I.)	509,694 (N.)
10	Percentage of total working expenses upon total earnings		50·733	62·475 (E. B.)	35·27 (E. I.)
	Coaching Traffic.				
11	Average coaching receipts per train-mile . . .	,,	3·33	3·99 (E. I.)	2·66 (O. & R.)
12	Average sum received for carrying a passenger unit (of all classes) 1 mile .	Pies	2·534	2·72 (G. I. P.)	1·96 (M.)
13	Average sum received per ton-mile for other coaching traffic	,,	36·109	54·89 (E. B.)	22·04 (N.)
14	Average total number of passenger units in a train		223·184	285·07 (M.)	163·475 (G. I. P.)
15	Average other traffic in a coaching train . . .	Tons	2·372	3·635 (N.)	0·97 (O. & R.)
16	Average number of vehicles in a coaching train . .		17·28	19·72 (E. I.)	15·07 (E. B.)
17	Average freight weight of a coaching train . . .	,,	16·018	20·09 (M.)	12·175 (O. & R.)
18	Average dead weight of a coaching train . . .	,,	198·15	232·005 (N. W.)	171·24 (E. B.)
19	Average total weight of a coaching train . . .	,,	214·168	249·475 (N. W.)	184·525 (G. I. P.)
20	Percentage of freight weight to dead weight in a coaching train		8·08	..	..

WORKING of the PRINCIPAL INDIAN RAILWAYS DURING 1886.

Metre-gauge Railways.			Differences between Means.	
Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.	5 feet 6 inches Gauge in excess.	Metre-gauge in excess.
62,595	87,230 (N. B.)	39,268 (R. K.)	105,505	
3·923	7·13 (R. M.)	1·82 (S. M.)	1·262	
128·40	228·50 (R. M.)	65·0 (M.)	218·10	
77·125	114·50 {(R. M.) (N. C.)}	38·50 (M.)	87·675	
51·275	114·0 (R. M.)	26·50 (M.)	130·425	
3·034	4·14 (R. K.)	2·36 (B. & N. W.)	1·246	
1·893	2·66 (N. C.)	1·345 (B. & N. W.)	0·219	
1·141	1·63 (N. B.)	0·715 (S. M.)	1·027	
10·613	13·115 (N. C.)	6·735 (B. & N. W.)	..	3·579
406,972	690,055 (R. M.)	154,396 (M.)	804,457	
62·943	76·585 (N. C.)	50·69 (R. M.)	..	12·21
3·004	4·82 (R. K.)	2·38 (N. C.)	0·326	
2·624	4·78 (R. K.)	1·88 (T.)	..	0·09
51·90	74·37 (R. K.)	33·595 (R. M.)	..	15·791
206·46	264·59 (S. I.)	152·53 (N. C.)	16·724	
1·048	2·615 (R. K.)	0·30 (C. A.)	1·324	
20·77	27·525 (B. & N. W.)	17·81 (S. M.)	..	3·49
13·563	16·425 (S. I.)	10·34 (B.)	2·455	
132·847	166·13 (B. & N. W.)	111·50 (B. G.)	65·303	
146·41	179·72 (B. & N. W.)	123·94 (B. G.)	67·758	
10·21	..	..	..	2·13

TABLE IV.—STATISTICS and PARTICULARS RELATING to the WORKING

No.	Heading.		Railways of 5 feet 6 inches Gauge.		
			Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.
	Coaching Traffic—continued.				
21	Average cost of hauling a coaching train 1 mile .	Rs.	1·485	1·815 (E. B.)	1·185 (E. I.)
22	Average cost of hauling a passenger unit 1 mile .	Pies	1·123	1·38 (E. B.)	0·825 (E. I.)
23	Average profit on working a coaching train 1 mile .	Rs.	1·845	2·805 (E. I.)	1·295 (N.)
24	Average profit on working a passenger unit 1 mile	Pies	1·411	1·88 (E. I.)	1·00 (M.)
	Goods Traffic.				
25	Average goods receipts per goods train-mile . . .	Rs.	4·825	7·125 (B.D.&C.I.)	3·205 (O. & R.)
26	Average sum received for carrying 1 ton of goods 1 mile	Pies	7·436	8·83 (E. B.)	4·62 (O. & R.)
27	Average total number of vehicles in a goods train		28·47	39·17 (B. B. & C. I.)	19·97 (N.)
28	Average load of a goods vehicle (including both loaded and empty) . .	Tons	4·719	5·96 (E. I.)	3·94 (E. B.)
29	Average load of a loaded goods vehicle . . .	"	6·603	8·175 (E. I.)	5·045 (M.)
30	Average freight weight of a goods train	"	128·675	189·22 (E. I.)	81·97 (N.)
31	Average dead weight of a goods train	"	229·196	290·49 (B. B. & C. I.)	185·50 (N.)
32	Average total weight of a goods train	"	357·871	467·385 (B.B.&C.I.)	267·47 (N.)
33	Percentage of freight upon capacity hauled . . .		48·928	56·77 (E. I.)	41·62 (O. & R.)
34	Percentage of freight weight upon dead weight of a goods train		56·14	..	..
35	Average cost of hauling a goods train 1 mile . .	Rs.	2·469	3·57 (E. B.)	1·865 (N.)
36	Average cost of hauling a goods unit (1 ton) 1 mile	Pies	3·93	5·86 (E. B.)	2·15 (E. I.)
37	Average cost of hauling a goods unit (1 ton) 1 mile, including interest on capital expended on open line at 5 per cent. per annum . .	Pies	8·85	16·25 (N.)	4·60 (E. I.)
38	Average profit on hauling a goods train 1 mile . .	Rs.	2·356	4·07 (B. B. & C. I.)	1·14 (M.) 1·14 (O. & R.)
39	Average profit on hauling a goods unit (1 ton) 1 mile	Pies	3·506	5·31 (N.)	1·545 (O. & R.)

of the PRINCIPAL INDIAN RAILWAYS DURING 1886.—*continued.*

Metre-gauge Railways.			Differences between Means.	
Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.	5 feet 6 inches Gauge in excess.	Metre-gauge in excess.
1·544	2·17 (N. C.)	1·035 (R. M.)	..	0·059
1·37	2·065 (N. C.)	0·83 (R. M.)	..	0·247
1·46	3·33 (R. K.)	0·21 (N. C.)	0·385	
1·254	2·985 (R. K.)	0·02 (N. C.)	0·157	
2·735	4·14 (N. C.)	2·075 (R. K.)	2·09	
8·195	12·24 (B. G.)	5·625 (B. & N. W.)	..	0·759
25·199	33·37 (B.)	17·83 (S. I.)	3·271	
2·74	3·76 (R. M.)	2·10 (M.)	1·979	
3·896	5·10 (R. M.)	2·81 (M.)	2·707	
66·587	86·90 (R. M.)	45·155 (M.)	62·088	
118·163	138·79 (C. A.)	94·505 (S. I.)	111·033	
184·75	222·905 (B.)	148·545 (S. I.)	173·121	
47·77	58·665 (R. M.)	36·74 (M.)	1·158	
56·37	..	..	..	0·23
1·930	2·805 (N. C.)	1·35 (B. & N. W.)	0·539	
6·036	8·125 (M.)	3·475 (B. & N. W.)	..	2·106
11·762	19·92 (R. K.)	6·515 (R. M.)	..	2·912
0·805	1·565 (N. B.)	0·235 (C. A.)	1·551	
2·159	4·57 (B. G.)	0·42 (C. A.)	1·347	

TABLE IV.—STATISTICS and PARTICULARS RELATING to the WORKING

No.	Heading.	Railways of 5 feet 6 inches Gauge.		
		Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.
	Percentages to Total Earnings.			
40	Percentage of coaching earnings to total earnings.	34·399	41·805 (O. & R.)	20·59 (G. I. P.)
41	Percentage of goods earnings to total earnings	62·297	78·435 (G. I. P.)	51·725 (O. & R.)
42	Percentage of sundry and telegraph	2·437	6·47 (O. & R.)	0·975 (G. I. P.)
43	Percentage of steamboat earnings [1]	0·867	..	..
	Totals	100·000		
	Percentages of Working Expenses upon Total Earnings.			
44	Maintenance of way, works, and stations	14·153	18·945 (E. B.)	11·72 (E. I.)
45	Locomotive expenses	15·809	20·785 (M.)	9·16 (E. I.)
46	Carriage and wagon expenses .	4·864	6·315 (N. W.)	3·045 (E. I.)
47	Traffic expenses	8·528	12·78 (E. B.)	6·07 (B.B.&C.I.)
48	General charges	5·287	7·92 (N.)	3·25 (G. I. P.)
49	Miscellaneous expenses . . .	1·558	3·265 (E. B.)	0·50 (M.)
50	Steamboat expenses [1]	0·627	4·125 (E. B.)	..
51	Total working expenses . . .	50·826	62·795 (E. B.)	35·285 (E.)
	Cost and particulars of Maintenance of Way, Works, and Stations.			
52	Mean age of line maintained Years	17·375	24 (E. I.)	7 (N.)
53	Cost per mile of line maintained . . . . . Rs.	2,589·27	4,116·70 (E. B.)	1,308·07 (O. & R.)
53a	Cost per mile of track including sidings . . . „	1,966·625	3,130 (E. B.)	1,097 (N.)
53b	Cost of maintenance of permanent way alone per mile of track including sidings . . . . . „	1,132·75	1,981 (E. B.)	475 (O. & R.)
54	Cost per total train-mile . Annas	9·763	13·925 (E. B.)	6·95 (O. & R.)
55	Cost per 1,000 gross ton-miles Rs.	2·05375	3·16 (E. B.)	1·46 (O. & R.)
	Cost and particulars of Locomotive Expenses.			
55a	Average mileage run by each engine per diem	50·24	59·96 (E. B.)	41·93 (N. W.)
56	Locomotive expenses per train-mile . . . . Annas	10·42	12·84 (G. I. P.)	7·555 (E. I.)
57	Locomotive expenses per engine-mile . . . . „	9·083	11·545 (G. I. P.)	6·65 (E. I.)

[1] Steamboat earnings appear only in the case of the East Indian, North Western, and Northern Bengal, and Bengal and

of the PRINCIPAL INDIAN RAILWAYS DURING 1886.—*continued.*

Metre-gauge Railways.			Differences between Means.	
Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.	5 feet 6 inches Gauge in excess.	Metre-gauge in excess.
43·04	61·90 (M.)	18·705 (N. C.)	..	8·641
50·557	80·195 (N. C.)	28·87 (R. K.)	11·74	
4·152	23·645 (R. K.)	1·05 (R. M.)	..	1·715
2·25	..	..	..	1·383
99·999				
16·710	26·70 (N. C.)	9·255 (C. A.)	..	2·557
17·296	23·905 (S. M.)	10·785 (R. K.)	..	1·487
4·885	15·655 (C. A.)	1·995 (R. K.)	..	0·021
10·652	15·175 (C. A.)	6·865 (N. B.)	..	2·124
10·252	14·61 (R. K.)	5·865 (R. M.)	..	4·965
1·888	10·525 (R. K.)	0·42 (S. I.)	..	0·33
1·537	7·22 (T.)	..	..	0·91
63·22	76·585 (N. C.)	50·69 (R. M.)	..	12·394
5·4545	13 (S. I.)	1 (S. M.)	11·9205	
1,219·85	2,184·72 (N. C.)	507·05 (R. K.)	1,369·42	
1,084·27	1,946 (N. C.)	477 (R. K.)	882·355	
640·363	1,385 (N. C.)	268 (B. & N. W.)	492·387	
8·604	15·03 (N. C.)	5·315 (B. & N. W.)	1·159	
3·25363	4·44 (S. I.)	1·69 (B. & N. W.)	..	1·19988
47·207	61·69 (B.)	33·07 (M.)	3·033	
8·341	11·83 (N. C.)	6·525 (T.)	2·079	
7·447	10·68 (N. C.)	5·155 (T.)	1·636	

Eastern Bengal Railways of 5 feet 6 inches gauge, and in the case of the Tirhoot, North Western Metre-gauge Railways.

TABLE IV.—STATISTICS and PARTICULARS RELATING to the WORKING

No.	Heading.		Railways of 5 feet 6 inches Gauge. Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.
	Cost and particulars of Locomotive Expenses—continued.				
58	Locomotive expenses per 1,000 gross ton-miles .	Rs.	2·2756	2·955 (M.)	1·325 (E. I.)
58a	Cost of fuel per ton[1] . .	Rs.	11·476	17·08 (M.)	2·43 (E. I.)
58b	Consumption of fuel per train-mile[1]	lbs.	43·24	48·68 (G. I. P.)	37·30 (M.)
58c	Consumption of fuel per 1,000 gross ton-miles[1] . .	"	150·877	184·72 (E. B.)	114·64 (B.B. & C.I.)
58d	Locomotive expenses per 1,000 gross ton-miles omitting cost of fuel .	Rs.	1·514	2·04 (G. I .P.)	1·19 (E. I.)
	Amount and particulars of Carriage and Wagon Expenses.				
59	Carriage and wagon expenses per total train-mile	Annas	3·249	4·205 (N. W.)	1·83 (N.)
60	Carriage and wagon expenses per 1,000 vehicle-miles run by home vehicles	Rs.	9·149	13·065 (G. I. P.)	5·355 (O. & R.)
60a	Average annual mileage run by a coaching vehicle	Miles	34,384	53,088 (E. I.)	25,189 (M.)
60b	Average annual mileage run by goods vehicle .	"	12,971	20,231 (E. I.)	6,803 (N.)
	Amount and particulars of Traffic Expenses.				
61	Traffic expenses per total train-mile	Annas	5·701	9·37 (E. B.)	4·62 (O. & R.)
61a	Average distance between stations	Miles	6·985	8·81 (E. I.)	4·03 (E. B.)
61b	Average total annual train-mileage per mile worked	"	3,993·75	5,736 (G. I. P.)	2,099 (N.)
62	Average through speed per hour of coaching-trains .	"	20·41	26·245 (E. I.)	17·405 (N. W.)
63	Average through speed per hour of goods trains .	"	11·009	12·22 (E. B.)	9·975 (O. & R.)
64	Average through speed per hour of mixed trains .	"	14·511	17·31 (E. I.)	12·32 (N. W.)
	General Charges.				
65	Cost of general charges per total train-mile . . .	Annas	3·438	499 (N.)	2·335 (G. I. P.)

[1] On lines burning wood, the wood consumed has been reduced to coal at the

of the PRINCIPAL INDIAN RAILWAYS DURING 1886—*continued.*

Metre-gauge Railways.			Differences between Means.	
Mean.	Maximum, and Railway where it occurs.	Minimum, and Railway where it occurs.	5 feet 6 inches Gauge in excess.	Metre-gauge in excess.
3·1408	3·86 (M.)	2·31 (B. & N. W.)	..	0·9652
15·315	23·38 (S. M.)	7·05 (N. C.)	..	3·839
31·394	65·93 (N. C.)	18·83 (R. K.)	11·846	
191·48	312·97 (N. C.)	131·39 (B.)	..	40·603
1·937	2·28 (N. C.)	1·49 (B. & N. W.)	..	0·423
2·273	6·845 (C. A.)	0·76 (T.)	0·976	
6·044	14·22 (C. A.)	2·445 (B. & N. W.)	3·105	
28,020	41,149 (B.&N.W.)	12,511 (M.)	6,364	
9,948	14,032 (N. B.)	5,357 (B. G.)	3,023	
5·059	8·18 (R. K.)	3·47 (S. I.)	0·742	
7·23	8·31 (N. B.)	6·17 (B.)	..	0·245
2,251	3,679 (R. M.)	1,059 (M.)	1,894·75	
15·954	18·185 (N. B.)	10·98 (M.)	4·456	
11·0315	14·31 (N. C.)	8·955 (R. M.)	..	0·225
12·9575	14·55 (N. C.)	10·98 (M.)	1,5535	
5·085	9·725 (R. K.)	2·80 (R. M.)	..	1·647

accepted equivalent of 3 parts of wood to 1 part of coal.

Discussion.

.tkinson. Mr. W. Atkinson said he was sure that the members had been much struck with the enormous amount of information conveyed in the Paper, and with the great pains taken by the Author in gathering from so many statistical papers the information he had laid before them. The subject was of the greatest interest, especially in view of the discussion which took place some years ago, perhaps the longest that had ever taken place in that room. The opportunity afforded in India for comparing the results of the two classes of railways was not perhaps equalled in any other country. There were 8,000 miles of railway of the 5 feet 6 inches gauge, and 5,000 miles of the metre gauge; thus offering an excellent opportunity for comparing results. In dealing with the subject the Author had selected eight railways of 7,648 miles 5 feet 6 inches gauge, and twelve railways comprising 4,421 miles of metre gauge. The former, however, represented trunk lines running between very important parts of the empire, while the greater part of the latter were simply feeder lines of comparatively small importance, but included the Rajputana metre-gauge line which was said to be of the nature of a trunk line. It would have been exceedingly appropriate if the Author had taken that line and any other line of 5 feet 6 inches gauge, which in its physical conditions, summits, grades, and curves, at all approximated to it. A fair comparison could then have been made, and the subject would have been worthy of discussion. At present he did not think it was so, because the Author had admitted that he was, to a great extent, comparing trunk lines with feeder lines. Then, again, the whole argument of the Paper was based upon the figures in the Table of means, and he strongly objected to the way in which it appeared they had been obtained, and thought he should be able to prove that they were not reliable. In the first place, in addition to a mean for the eight railways of the one gauge, and the twelve of the other, he had selected from each class that which represented the highest and the lowest; and by an inspection of the Nos. 14 to 19 of the 5 feet 6 inches gauge, it seemed certain that the means were wrong, and even that they might have been taken from the highest and lowest. But such a result would not be a mean, no account having been taken of the other lines. The remaining alternative was that the whole of the lines had been

taken into account, and that their individual means had been added together, and divided by the number, giving a mean of means, and not a mean of totals, no multiplier of totals having been used. It would be seen, therefore, that the whole Table was perfectly valueless. It would be useless to pursue the investigations further, because all the figures were worked out in the same way. The Author had assumed that £100 had been equally spent on each line, instead of a large amount on one and a very small amount on another. And so with regard to the earnings per mile per week. That being the case, the subject moreover being one of great importance, and the Author being evidently a man of great application and research, if he would take into account these criticisms and other observations that would, no doubt, be made, he might, at some future time, lay before the members an exceedingly valuable Paper. Mr. Atk

Sir Bradford Leslie, K.C.I.E., thought the Institution was greatly indebted to the Author for his very complete and interesting Paper contrasting the broad and narrow-gauge railways of India. His investigation of the causes of the higher cost of the broad-gauge lines left nothing to be added, unless, perhaps, it was that the convenience of the public had been studied in more roomy and superior coaching stock, and better station accommodation, on the broad than on the narrow-gauge lines. The greater height of the broad-gauge stock gave some 20 per cent. more cubical capacity per passenger-unit than on the narrow-gauge stock, a consideration of much importance to the teeming multitudes who filled the lower-class vehicles in the tropical climate of India. As to the working expenses, he would venture to make a few observations, based on the figures given in Table IV. Administration charges, general management, superior supervision, and station staff were, to a considerable extent, independent of traffic fluctuations. The distinction between fixed and fluctuating charges was not clearly marked. Some expenses, such as train-staff and fuel, varied almost directly with the traffic; others, as station-staff, maintenance and repairs, were affected less directly by the volume of traffic. On a well-managed line in India he believed that the fixed charges could not be taken at less than Rs.30 per mile per week; with that reserve he thought it might be assumed that other charges varied directly with the traffic. The consequence was that the cost of working was in inverse proportion to the volume of traffic. It was evident that a traffic of Rs.346·5 per mile per week (item 3) must be more cheaply worked than one of only Rs.128·4 per mile per week. To ascertain what the cost of working the metre-gauge Sir Brad Leslie.

adford lines would be, if they enjoyed a traffic equal to that of the standard gauge lines, he divided their present cost of working (item 4) into fixed charges, Rs.30, and fluctuating expenses Rs.$47\frac{1}{8}$; multiplying the latter by 2·7 (the ratio of broad to narrow-gauge receipts), the total expenses, including fixed charges, would be Rs.157, which was $4\frac{1}{2}$ per cent. less than the present cost of working the broad-gauge lines. Conversely, if the traffic of the broad-gauge lines dropped to the level of that of the metre-gauge lines, it might be shown that their working expenses would be greater than that of the metre-gauge lines, and would be $62\frac{1}{3}$ per cent. of the receipts against 60 per cent. on the metre-gauge lines (shown as 62,943 in item 10, p. 38). If all other circumstances were equal, those considerations would show that the cost of transport on the metre gauge was at least as economical as on the standard gauge. It should, however, be borne in mind that the average age of the stock and block of the metre-gauge lines (item 52) was less than one-third of that of the standard-gauge lines, and as their ton-mileage was only one-third of that of the standard-gauge lines, the wear and tear on the metre-gauge lines had really only been one-ninth part of that of the standard-gauge lines. The average tons travel to which the metre-gauge rails had been subjected must be under 20,000,000, probably not more than 12,000,000, so that if the rails originally laid had been suitable in weight and section to the traffic, their life should not yet be exhausted. The same observations applied to sleepers, while the expense of maintaining the rolling-stock should hitherto have been limited to partial repairs and replacement of stock accidentally destroyed. In point of fact, the metre-gauge lines had not yet exhausted their "newness," or reached the period when annual renewals of permanent way and rolling-stock were required in proportion to wear and tear. It was not until the East Indian Railway had been opened for twenty years that the renewals of rails became a heavy charge upon maintenance. Since 1880 about 50 per cent. of the line had been relaid with steel rails, but there were still many of the original 20 feet rails in the line. That favourable result was due to the use of double-headed rails, all of which were turned. In the same way, it was twenty years after the opening of the line before any locomotive engines were condemned, and the first engines condemned had seen some twenty-five years' service. Since 1880, eighty locomotives had been replaced at the cost of revenue. The same observations applied to the carriage and wagon stock, the rebuilding and renewal of which on a large scale dated only from twenty years after the opening

Sir Bradford Leslie.

of the line. The working of the Great Indian Peninsula, the Bombay and Baroda, the Eastern Bengal and other lines of heavy traffic, that had been opened for twenty years and upwards, was also burdened with the cost of regular annual renewals of permanent way and rolling-stock, from which the metre-gauge lines should be free for many years to come. It appeared, therefore, that any comparison between the cost of working the metre-gauge lines, with an average age of 5·45 years, and of the broad-gauge lines with an average age of 17·37 years must be to a great extent fallacious and misleading. Having regard to the "newness" of the metre-gauge lines, the cost of working even their limited traffic should compare more favourably with the cost of working the broad-gauge traffic than it did. That this was not the case was primarily due to the inferior and weaker type of permanent way, introduced on the metre-gauge lines, as compared with the solid track of the broad-gauge lines. The first metre-gauge lines were laid with 30 and 36-lb. rails; the small depth of those rails caused them to be deficient in vertical stiffness, and did not afford space in the vertical web for efficient fish-jointing, and the section was soon found to be too light for the traffic, and had been abandoned for 41¼ and 50-lb. rails. The small sleepers originally supplied to the metre-gauge lines were often cut from immature trees and branches; they were soon split by the heat of the sun, and gave no sufficient bearing for the rails, or hold for the rail spikes. For those reasons the original permanent way of the metre-gauge lines was costly to maintain. When the metre-gauge lines had been relaid with 50 or 56-lb. rails, improved fish-joints, and iron or steel sleepers well ballasted, it was probable that the cost of maintaining the permanent way would compare more favourably with that of the broad-gauge lines; but the considerable overhang of the engines and rolling-stock must always be a disadvantage. Owing to the cant of the rails necessary for fast trains on curves, the greater portion of the weight of low-speed goods trains was thrown on the inner rail; and even on straight portions of the line, the slack coupling and greater oscillation, due to the overhanging weight, was more severe on the rails than on the broad gauge, where most of the weight was carried between the rails; again, owing to the small diameter of the driving-wheels, the pulsations of the engine were more numerous and more destructive than on the broad gauge. Probably the most irremediable defect in the metre-gauge lines was the inferiority of the locomotive-engines, the efficiency of which, excluding fuel, as shown by the Author (item 58d), was 28 per cent. less than that of the broad-gauge

Bradford
slie.

engines, and, including coal at one-fourth of the total locomotive charges, would amount to 38 per cent. less. If that were the case while the metre-gauge engines were comparatively new, it was probable that when, in the course of time, the cost of locomotive renewals was added to the other expenses, their inferiority to the broad-gauge engines in economy of working would be not less than 50 per cent. The inferior results obtained from the metre-gauge locomotive stock was due to a variety of causes, among which might be cited: (1) Heavier incidence of wages, as the metre-gauge engine staff cost practically the same as the broad gauge, and hauled only half the train-load at three-quarters of the speed attained on the broad gauge; (2) greater engine and train friction, owing to small diameter of wheels, short cranks, and smallness of working parts; (3) contracted area of grate surface, requiring harder firing, and involving difficulty in keeping steam at a steady pressure; (4) 40 per cent. increased consumption of fuel, due to causes 2 and 3. It was possible that by the use of liquid fuel, and by the employment of native drivers, better results might be obtained from the metre-gauge engine, but engine and train friction, and consequently cost of repairs, would always be greater on the narrow gauge than on the broad. The cost of rolling-stock per unit of carrying capacity was practically the same on the broad and on the narrow gauge, while the mileage of the narrow-gauge stock (item 60b) owing to inferior speed of trains was $23\frac{1}{3}$ per cent. less than that of the broad-gauge stock; therefore, for equal traffic, the broad gauge required $23\frac{1}{3}$ per cent. less carrying capacity of rolling-stock. The evils of break of gauge had not been over-estimated. On the last occasion of the despatch of a military force from India to Egypt, troops were sent from the Punjab round by Allahabad and Jubbulpore to Bombay, an extra distance of 320 miles as compared with the direct route by the metre-gauge Rajputana Railway, which would have involved break of gauge at Delhi and Sabarmati.

. Shelford.

Mr. W. SHELFORD understood Sir Bradford Leslie to admit that if the traffic upon the broad-gauge lines was reduced to the quantity which was carried by the metre-gauge lines, the working expenses of the former would be greater than those of the latter. Was not that a strong argument in favour of the metre-gauge lines where the traffic was light? It appeared to him that people were in the habit, in considering that question, of forgetting the real problem to be solved. On the broad-gauge lines as much weight as possible had to be carried at the lowest possible price. Where the traffic was light, and where narrow-gauge lines were suitable,

the smallest possible amount of traffic that would pay had to be carried. Again, it seemed to him that there was always some misapprehension about the importance of the question of gauge. He was rather inclined to think that what had been said was true, that of all things which constituted a railway the gauge was perhaps the least important. On the occasion of the great debate before the Institution upon the gauge of Indian railways, sixteen years ago, the question turned mainly upon the break of gauge, and upon the relative cost of construction. At that time there were scarcely any narrow-gauge railways in existence, and there were no figures to go upon as to the cost of working. The Author had now given some figures which would serve for the purpose of discussion. Mr. Atkinson's criticism upon them appeared to him to be scarcely fair. The Author had stated at the end of his Paper, "He has, as far as possible, endeavoured to avoid the expression of any opinions of his own, unless they were amply borne out, in his judgment, by the facts and figures adduced, if not, indeed, almost logical conclusions from them." He thought that any one reading the Paper must feel that there was a strong colouring of broad gauge about it, and the same thing might be said with regard to the discussion as far as it had gone. He therefore desired to put before the members a somewhat different view, which he would draw from the Author's own figures, and he begged to state that he was at least as unbiassed as the Author himself. It would be observed that the Paper dealt with totally different traffic on the narrow gauge as compared with the broad gauge. That was shown by the statement that the mean total weight of the traffic, passing over each mile of the railways of the standard gauge, was nearly three times as much as that conveyed over each mile of the metre-gauge lines. It was also shown in another place that the average freight, dead, and total weights of goods trains were 94 per cent. greater upon lines of the 5 feet 6 inches gauge; in other words, the average freight of goods trains on the metre-gauge lines was about half the amount on the broad-gauge lines. There was a further statement in the Paper that on the broad-gauge lines the trains carried "a somewhat larger number of passengers" than on the narrow-gauge lines. It appeared from Table IV that that "somewhat larger number" of passengers was only about 10 per cent. Obviously, therefore, in the broad-gauge system of India there was a heavy goods traffic, double that of the narrow-gauge lines, and a passenger traffic nearly equal. It might have been thought that the Author would have compared like with like, and have adopted figures which most nearly approached each other, drawing his con- Mr. Shelfo

r. Shelford. clusions rather from the passenger traffic than from anything else. But he had in several particulars taken ton-miles as the unit of comparison, maintaining that that was the only proper standard. Mr. Shelford wished to point out, by means of illustrations which were familiar to him, the fallacy of that course. He was intimately acquainted with the Hull and Barnsley Railway, which carried a heavy goods traffic and a small passenger traffic, and also with the Crystal Palace High Level Railway, which carried a large passenger traffic and a small goods traffic. The cost of a train per mile upon each of those lines was somewhat similar, but the weight of the trains on the Hull and Barnsley line was fully four times that on the High Level Crystal Palace line. Working it out in ton-miles, the result would be that the Hull and Barnsley Company's expenses were one-fourth of those on the High Level Crystal Palace line. He therefore considered that the ton-mile was, in certain cases, the most improper unit to apply in comparing two railways. In Canada and in the Western States of America, where the population was sparse, it was a proper unit, because there the object of the railway was to carry heavy freights at a low rate for long distances, and experience had shown that narrow-gauge railways were not suitable for America, for that among other reasons. In the case under discussion, however, the passenger traffic on the metre-gauge system was equal to the passenger traffic on the broad-gauge system, and the goods traffic was very different. He would suggest, therefore, that the proper unit to take was the train-mile, because the train-mile represented the accommodation given to the population, and nothing represented it so well. It was a unit universally adopted in this country, although he admitted that it was sometimes misused. It had been animadverted upon at the meetings of the Institution, but it was the usual unit, and it would be interesting to see the effect of it as applied to the Author's figures. He would first refer to item 7 on the Table of general results—"Total working expenses per train-mile." The Author, in the body of the Paper, had given the percentage in this case at 11½ per cent. in favour of the narrow-gauge system. In regard to item 20 "Percentage of freight weight to dead weight in a coaching train," the figure given in the body of the Paper was 2·13 per cent.; but that was an obvious error, it ought to be 26 per cent. in favour of the narrow-gauge system. Taking item 35, "Average cost of hauling a goods train 1 mile," the difference was 27 per cent. in favour of the narrow gauge. The difference in favour of the narrow gauge in cost of maintenance of way, works and stations,

was 13 per cent.; locomotive expenses per train-mile, 25 per cent.; locomotive expenses per engine-mile, 21 per cent.; consumption of fuel per train-mile, 37 per cent.; carriage and wagon expenses per total train-mile, 43 per cent.; traffic expenses per train-mile, 14 per cent. These were a few examples of what was shown in the Paper in favour of the narrow gauge, if measured as it properly should be by the accommodation given, and that could only be done in this case by the train-mile. In other countries—in England where there was very little narrow-gauge, in Ireland where there was a great deal more, as well as in Germany and in Italy, the experience was precisely the same, namely, that where narrow-gauge railways were suitable, the cost per train-mile was less than on the broad-gauge lines. He was not at all biassed in the matter, being a maker of both broad and narrow-gauge railways; but his view was that that railway was best suited to a country, and was the most economical, which was worked up to its full capacity. He had held that view for some time, and he was glad that it was corroborated by a Blue-book on the "Relative Merits of Broad and Metre-gauge Lines of Railway," No. ccxxxviii, Serial No. 13, 1888, published last year by the Indian Government. It contained a dispatch from the Public Works Department, in which there were these words: "We may quote with approval, as bearing on this question, the following passage from Major Conway-Gordon's note:—'The principle underlying all questions of gauge is, that a machine is, comparatively speaking, economical only when working at its full power. The best gauge for any particular railway is, therefore, merely a question of the amount and description of traffic that will probably come on the line, and it is consequently a question that ultimately hinges, not on the cost of the construction, but on the cost of working, including the interest on the capital expended.' They also quoted from a memorandum of Mr. W. C. Furnivall, who stated: 'The broad gauge is a more efficient carrying machine than the narrow gauge. Trains travel faster on the broad gauge, than upon the narrow gauge, and carry more; and if the traffic is of sufficient magnitude to fully employ the larger machine, the carrying expenses are less, but the difficulty in making a choice lies in correctly estimating the circumstances of the different tracts of country through which it is now desirable to extend railway communications.'" Those views were in accordance with his own, and he believed that they were thoroughly sound. He regretted that he could not altogether agree with the logical conclusions of the Author. He was much interested in arriving at the truth on the question, and he was

Shelford. therefore anxious that any statements submitted should be criticised and challenged if they were not correct. He hoped the views he had expressed would not be altogether unsupported.

Giles. Mr. A. Giles, M.P., Vice President, said, as many of those present would remember the great battle of the gauges, he would simply ask how many miles of broad-gauge lines were still left? It would be found from the statistics in the Paper that out of the 13,000 miles of railway in India five-eighths of them were of the metre gauge. In a new country like India it was right to make a cheap and narrow-gauge railway instead of going to work with the more expensive system. In America cheap lines had been constructed of all gauges. The timber for sleepers was cheap, and the lines were not fenced nor ballasted; and in the Paper under discussion it was stated that many of the metre-gauge lines in India were neither ballasted nor fenced. A metre-gauge line must of necessity be much cheaper than one of 5 feet 6 inches gauge. There was less weight of sleepers, less weight of rails, less weight of engines and carriages, and less height for the bridges. The Government of India, therefore, was perfectly right in adopting cheap railways for the traffic. Another point had struck him in reading the Paper, namely, that out of the 13,000 miles of railways in India only one-fifteenth of the whole were double lines. When it was found that an important line like that between Bombay and Calcutta was not yet doubled, he thought the lesson might well be taken to heart, and the Board of Trade be asked not to make the construction of double lines for traffic compulsory. Railway companies had been obliged in many cases to make double lines where a single line would have answered every purpose. Of course in the case of enormous traffic like that on the Midland, the North Western, the Great Northern, and other large lines, two or even four lines might not be sufficient, but that point had not yet been reached in India. No doubt in time the main trunk lines would be doubled. He thought the best policy was to make a single line first, and when the traffic increased, to double it. It would be cheaper in a poor country to make a metre-gauge line first, and when the traffic required, to take it up and relay it as a broad-gauge line, than to spend all the money at first and let so much extra capital lie idle while the traffic was increasing.

Lewis. Mr. W. B. Lewis was surprised that Mr. Giles, in referring to railways in America, did not remember that they were of the ordinary English gauge of 4 feet 8½ inches, and that cheap railways of this gauge were made there first. He thought that if in India one gauge had been adhered to, but a lighter railway made, like

Mr. Lewis. results might have been obtained. The railways could have been constructed nearly as cheaply, and the great difficulty of break of gauge, which had been felt in this country and in America to be so serious, would have been obviated. When in the Southern States of America three years ago, he was delayed on a journey, and the reason given was that the last piece of railway was being altered to the standard gauge, and that when that was done, with the exception of the Denver system of lines, there would be one uniform gauge throughout the railways of the States and Canada. In Canada some narrow-gauge lines had been started, but these had been abandoned, and a uniform gauge adopted. At the discussion, sixteen years ago, the case of Victoria was mentioned. There a 5 feet 3 inches gauge had been introduced. Happily the making of the 3 feet 6 inches gauge, for which there was a great outcry, was stopped, and the uniform broader gauge was maintained. At first a 50-lb. rail was adopted, but it was speedily changed to a 60-lb. rail. The railways were made for £5,000 per mile, and some even for £3,500, as compared with the first extravagant expenditure of £30,000 or £40,000 per mile. When the traffic increased all that had to be done was to lay down a stouter rail, the rolling-stock being still available. That was an immense advantage, and he had yet failed to discover any reason that justified a change of gauge in India, seeing the enormous inconveniences which must result in cases of emergency. He believed that on the Indus Valley and other railways, the making of narrow-gauge lines was stopped by the military authorities, who pointed out how dreadfully hampered they would be in the event of war by a break of gauge on one of the main lines running north. And surely the trunk line in the south, with which the President was connected, might have been made of the same gauge as the other lines. In that way the inconvenience that must result some day would be obviated. At present he did not think that any commensurate expense had been saved.

Major-Gen. Williams. Major-General E. C. S. WILLIAMS, C.I.E., R.E., said that the Author had supported the statements of the Paper with a Table based upon the statistics of the working of Indian railways, given in the report of the Director-General of Railways for the year 1886. The maximum and minimum figures for specified railways in that Table were not questioned; but the so-called means, applicable to eight broad and twelve metre-gauge lines, were incorrect. Those means had apparently been derived from the Director-General's figures for the individual railways, by adding together those for the several lines of each gauge and dividing the respective

..r-General ..iams. totals by 8 and 12, without taking into account the varying length, traffic, cost, &c., of the different railways. All the figures had, in fact, been treated as of equal weight, and the Author's averages were not, therefore, true means. The original figures had, however, been treated alike for both gauges, and the true means, if calculated, might be held by the Author to justify his conclusions. In regard to the first cost of railways, it appeared (p. 86 of the Director-General's Report, 1886–87, presented to Parliament), that about 8,000 miles of broad-gauge railways had been made for Rs. 169,000 per mile, and about 5,000 miles of metre-gauge railways, had been made for Rs. 69,000 per mile, leaving on these means a difference of Rs. 100,000 to be accounted for; and it was the Author's view that the excess was due to two causes, the superior type of the broad-gauge lines, and the difficulties encountered in constructing them. The large cost of the trunk lines was no doubt, in some measure, due to their being the pioneer lines. Their capital account included the price at which India had bought her experience. In proof of this unavoidable want of experience of a new country on the part of a large staff suddenly imported, he might mention that before the Select Committee on Indian Railways of 1858, the trunk lines, then well started, were estimated to cost less than £10,000 a mile, whereas they had cost nearer £20,000. Connected as he had been with railways in India, more or less, since 1858, he should be the last person to throw a stone at those who had constructed the older lines. The Author had attempted an explanation of one item only of the excess, that of the bridging. It was quite true that the large bridges were chiefly on the broad-gauge lines; but it must not be supposed that they had a monopoly of them. In the Table of bridges, however, there was a mistake, for which the Director-General's Report was responsible, but which an engineer of the Author's capacity might have challenged, namely, that the Empress Bridge over the Sutlej, at Adamwahan, had cost two and three-quarters crores of rupees, but the two crores had got in by mistake. He did not want to press that point. He was quite prepared to give more than was asked for. Taking all the big bridges mentioned in the Table, in addition to their protective works, and including the balance of the cost of the "Jubilee" Bridge over the Hooghly, the Calpi-Jumna, the Dufferin at Benares, and the biggest bridge in India, soon to be opened, namely, that over the Indus at Sukkur, their cost might be put at 1,000 lacs of rupees, and credit might be taken for Rs. 12,500 per mile over the 8,000 miles of broad-gauge railway on which these bridges existed. Deducting that sum from Rs. 100,000, there still remained an

Major-Gen. Williams.

excess of Rs. 87,500 to account for. No one knew better than Sir Bradford Leslie that the East Indian Railway had a great deal to go through in the time of the Santhal Rebellion, and in the Mutiny. The officers of that railway estimated that the Company was put to an extra expense of £3,000,000 sterling by those events, and by the abandonment of much unfinished line in the north-west, consequent on re-alignment on military grounds after the Mutiny, and he was willing for present purposes to accept that figure. Then, again, the Bombay and Baroda line was commenced in the middle, and not at its base, because people could not make up their minds to let it start direct from Bombay, so that without a single gradient and with no special works whatever except heavy bridging, it for many years held the unenviable position of being the most expensive line in India. In various ways several millions might be knocked off the cost of the old broad-gauge lines, but even then it would not be possible to bring the cost of the two systems to anything like an equality. As to prices, labour was cheaper in former days, but materials and freights were dearer. The price of iron rails had been as much as £12, and even £14 or £15, and freights were nearly £2 per ton. Quite lately steel rails could be obtained at £4 per ton, and freights had come down to £1 per ton, and had even been as low as 8*s.* per ton to Calcutta. Prices materially affected, also, the cost of the bridges, &c., in which iron or steel was used; but after making these allowances, and after allowing for the extra rolling-stock on the trunk lines with their heavier traffic, the great cost of their central workshops, the cost of inland carriage which the trunk lines now reduced so largely for the benefit of new railways, the cost of doubled portions of line and of works made years ago for doubling yet to be done, the inexperience of engineers and contractors of the peculiarities of the country, the failures of works, and so on, they would not account for the difference of a lac of rupees per mile. The end could not be arrived at through such averages, and until two railways were made side by side on the two gauges, and under the same conditions, there could only be controversy, of which he was heartily sick. Failing that, however, some of the more recently constructed broad-gauge railways might be closely compared (noting all the different circumstances) with some of the narrow-gauge lines, to arrive at a fair idea of the difference of cost. Some years ago he did that for the Rajputana and the Oudh and Rohilkhand Railways, and the conclusion at which he had arrived was that, allowing for the special bridging on the Oudh and Rohilkhand Railway, one of the later broad-gauge lines, traversing very flat

jor-General liams. country, there was a saving of Rs. 15,000 per mile on the Rajputana metre-gauge line. Dealing with the railway extensions of the last twenty years, it would be found that, omitting the South Indian Railway, 4,734 miles of metre-gauge railways had been made, at an average cost of about Rs.69,000 per mile, including rolling-stock sufficient to work the whole. And 1,588 miles of broad-gauge lines, including the Nizam's Railway and its recent extensions, also the original system of the Oudh and Rohilkhand Railway, had been constructed at an average cost of Rs.92,500 per mile; but about 500 miles had not been provided with rolling-stock. The North-Western Railway could not be included, with fairness, in any comparison, and was omitted. It embraced the old Sind, Punjab, and Delhi Railways, and the frontier lines on which the heaviest works in India were found, and its capital account was swelled by the direct, as well as by the indirect, effect of the change of gauge, about 240 miles having been more or less carried out on the metre gauge before the order to adopt the broad gauge was issued, by the partial use and subsequent abandonment of the Grand Trunk Road between Lahore and Jhelum (100 miles), and by the heavy cost of pushing work under political pressure. It seemed probable, however, that its cost would be covered by Rs.150,000 a mile. But in making such comparisons of individual recent lines as he had suggested, the physical character of the country and the precise nature of the works were not the only things to be considered. The position of the line with reference to the sea-board, and the fact of the railway being supplied or not with rolling-stock, workshops, and expensive terminal stations must be borne in mind. Neither ought generalizations to be drawn from special sections of line or from petty branches. As an instance of the former, it would be remembered that in the discussion of 1873, it had been averred that portions of the East Indian Railway in the North-West Doab had been made for less than the sum, per mile, at which it was then said the metre-gauge lines could be constructed. Doubtless this might be true for a section of surface-line with no important works to speak of, and no proportionate debits for adjuncts, conveniences, or exceptional works elsewhere. As an instance of the latter, there was the recently-constructed Tárakeshwar branch, 22 miles in length on the 5 feet 6 inches gauge, close to the seaport of Calcutta, made with second-hand rails on cast-iron plate sleepers, with no heavy works and without rolling-stock, workshops, general offices, staff quarters for more than the station and train staff, or goods accommodation, it being essentially a passenger line. Yet that

Major-Gen Williams.

branch had somehow cost Rs.77,757 per mile. But the Bengal Central might be taken, which, on the 5 feet 6 inches gauge, was a line, 125 miles in length, also close to Calcutta. It had been recently made for Rs.71,400 per mile, including Rs.8,355 for rolling-stock, but it was not ballasted (for which Rs.7,000 at least per mile would be required), and it had no general offices, workshops, or station at its chief terminus. Again, the Sindia Railway (5 feet 6 inches gauge, and 75 miles in length), now ten years old, was made for Rs.71,000 per mile, omitting the bridge over the Chumbal, and it had no rolling-stock, shops, or terminus at Agra, but it was 800 miles inland. The Patna-Gya line of the same gauge and age, and 57 miles in length, 300 miles from the sea, was made for Rs.74,600, but without stock, &c. At present there were under construction two large railway systems on the 5 feet 6 inches gauge, the Bengal-Nagpur and the Indian Midland, aggregating 1,250 miles in length, and, judging by the estimates, they were to cost when completed Rs.120,000 per mile, on the average. The original Nizam's Railway, fourteen and a half years old, and 117 miles in length, was made on the broad gauge for Rs.104,000, including a ghât incline. Its recent extensions, 233 miles in length, had been made for Rs.65,500 per mile, including Rs.7,500 for rolling-stock, but with land free except for 22 miles, no debits for share of workshops, general offices or terminal station at the capital, no bridges of magnitude, nor other heavy works, and fenced for only about one-tenth of its length. The combined system of 350 miles, however, stood well at Rs.78,400 per mile. The original system of the Oudh and Rohilkhand Railway, 547 miles in length, and on the broad gauge, was made and stocked for Rs.107,000 per mile, and when the comparison, already referred to, of its cost with 1,117 miles of the Rajputana metre-gauge railway was made, their respective ages were ten and three-quarter years, and five and a half years, and the cost of the latter was Rs.79,000 per mile, the rails, in each case, averaging over £9 per ton. As extended to 1,667 miles on the 31st of December, 1887, the average cost of the last, fully equipped, stands at Rs.74,000. Turning to more recently constructed metre-gauge lines, there was firstly, in Southern India, the large and costly system of the Southern Mahratta Co., made with expensive labour, and having a dozen large bridges aggregating close on 4 miles in length, one very stiff ghât, and two other ghâts involving heavy works, besides five tunnels aggregating $\frac{2}{3}$ mile in length, the outlay on which had been about Rs.85,000 per mile; but though opened throughout, the estimates showed about Rs.10,000 per mile

r-General iams. remaining to be spent. Its cost, therefore, might be Rs.95,000, of which the large bridges and tunnels were together responsible for more than Rs.21,000 per mile. In Upper India there was the little Rohilkhand-Kumaon made for Rs.40,000 per mile, upwards of 800 miles from the seaboard, and the Bengal and North-Western, 376 miles in length, beginning 300 miles from the sea, which had been made and stocked for Rs.60,000 per mile, inclusive of Rs.5,000 per mile for a big bridge. This last undertaking was the only surviving example of private enterprise applied to railways in India. The advocates of extensions on the broad gauge would not be able to gather much comfort from these examples of the cost of recent lines of both gauges, even after allowing for the effect of the varying rates of exchange on the portion of the outlay disbursed in England, and the exclusion of the loss by exchange from the railways constructed by the State. The English outlay on recent lines was less than one-fourth the total outlay; on the old lines it was more than one-third. But, before quitting that part of the subject, it was right that he should point out that in Madras there was what had been practically the cheapest broad-gauge line, and, even after conversion, about the cheapest metre-gauge line in India. He referred to the South Indian, one of the original heavy lines which, as now existing, 654 miles in length, had cost Rs.69,000 a mile, all found. There was still in Madras one heavy line, of which Sir George Bruce was the Engineer, and when its works and cost were compared with others of the old heavy trunk lines, or with recent broad-gauge lines, the President might point with satisfaction to its cost, not even now more than Rs.133,000 per mile. In these cases, as in those of all the old guaranteed lines, the loss by exchange was excluded. Finally, it might not be considered inappropriate to mention that, in a recent report on the question of railway extension on the east coast of India, between Bezwada and Cuttack, Sir Guilford Molesworth the Consulting Engineer to the Government of India for State Railways, and Colonel C. J. Smith, the Consulting Engineer to the Government of Madras for railways, officers of great experience and intimately acquainted with Indian Railways, had jointly adopted for purposes of comparative estimates of cost on the two gauges, Rs.81,000 for the 5 feet 6 inches gauge, and Rs.65,000 for the metre gauge; exhibiting a difference in favour of the metre gauge of Rs.16,000 per mile. But on none of the broad-gauge lines subject to general traffic had a rail of less weight than 60 lbs. to the yard been used, and it was asked, why not have built light lines on that gauge and so avoided the evil of break of gauge?

That question was fully considered before it was determined to face a break of gauge, and the conclusion, if that course were followed, was that the standard of the old trunk lines would be perpetuated in everything else, so that there would be little or no reduction of outlay, and in times of emergency, whether famine or war, the authorities would find that they were leaning upon a bruised reed. The incursions of the heavy stock of the trunk lines could not be avoided, and the line would be broken up just when most needed. Furthermore, that conclusion was not come to without considering that it might possibly be avoided by having a reserve of light engines. The attempt at a light broad line with the Oudh and Rohilkhand Railway, limited by contract to a 3½ tons wheel-weight and a speed of 15 miles an hour, was not successful. As actually made it was, to all intents and purposes, on the old standard with 60-lb. rails. No one preferred a break of gauge, but, except for military movements and by no means for all of them, a break of gauge was for India, with its huge distances and area, and its agricultural staples, a bugbear. It meant, moreover, less than 2*d.* a ton for cost of transhipment. In considering this matter of break of gauge, there was no analogy with little England, her close network of competing railways, her huge trade, the miscellaneous nature of that trade and the high intrinsic value of much of it, and its short leads. Moreover, now that one-third of the Indian railway system, or more than 5,000 miles, was on the narrow gauge, the objection to break of gauge cut both ways when extensions were contemplated. With the introduction of a different gauge, however, a new departure became possible, and, as evidenced by the results of the last eighteen years, a large mileage of less costly railway had been obtained for India. Granted that it was not as powerful a machine as the heavy broad-gauge railway, yet it had capacity enough for the general wants of India off the main routes, and it was an example of the adaptation of means to ends. In fact, except for fanciful military purposes, there need not have been a mile of heavy first-class line south of the Great Indian Peninsula Railway, for if the famine traffic of 1877, the period of trial of the Madras Railway, were added to the present ordinary traffic of that railway, the work to be done would still be less than one-half the work done on the East Indian Railway in 1887. He wished to speak in the presence of Sir George Bruce with every respect of the Madras Railway, but the President would, he trusted, permit him to call it an elephant, and a white one, too; for, made under a Government guarantee of 5 per cent., it had not as yet yielded more than

Major-Gene Williams.

jor-General lliams. 3 per cent., or thereabouts, though it was twenty-five years of age. The mention of that word "elephant" brought him to the point of the matter. When opening a section of the heavy Eastern Bengal Railway, at the time the policy of the Government in making railway extensions on a narrow gauge was bitterly assailed, the Viceroy, Lord Mayo, said: "When we have an elephant's load we may use an elephant; but when we have only a donkey's load we ought to use a donkey." The question of railway extension turned upon traffic, on the adaptation of means to ends, and therefore, primarily, on finance. All were familiar with the costermonger's cart by which so much of the distribution of the daily necessaries of life was done in London. Well, the narrow-gauge railways of India were the costermongers' carts of London. He preferred the term "donkey" to "toy," if contemptuous expressions were to prevail. The military authorities in India, according to Sir Charles Dilke, preferred the "mule" to the "camel." There was ground for hope, therefore, that having obtained the elephant for the frontier, and rightly so, one of the progenitors of the mule might yet be appreciated. The "donkey" had proved its worth in India as elsewhere; and where there was only a donkey's load to carry, he preferred to have six donkeys to even five elephants. India wanted communications badly. The country could not afford roads out of ordinary revenue, for repairs absorbed the funds which should go to make extensions, and tolls were impossible. A rail or tram-road which presented the public with advantages worth paying for, and which paid its own upkeep, was the desideratum. India could not find unlimited funds for railway extensions, good as her credit was thanks to her financiers and her railways, and it was therefore of the first importance to use the funds procurable to obtain the greatest mileage of railway, and of single track, as a rule; for should the traffic on any line become in excess of the capacity of a single track, the accommodation ought to be given rather by a totally distinct line of single-track railway, traversing new districts, but converging on the same outlet, so as to realise the intermittent pressure arising from the long distance through traffic, whilst affording railway facilities to new localities. The magnitude of India was such as to call for that, as well as to allow of it without adding materially to through leads between the interior and the seaboard. The general conclusion to which he had been led, by a close study of the facts of railway construction in India, was that, never mind how the saving was made in detail, at least 5,000 miles of the "donkey" might reasonably be expected to be made, or 4,000 miles

Major-General Williams.

of the "elephant," for about the same outlay. He could not support that view if he were not satisfied with the results of the working of metre-gauge railways. He did not intend to follow the Author in his examination of the details of the cost of working, which would involve the laborious process of correcting the averages of the Paper. He rested his case on the general results which were presented in the accompanying Table. These results were obtained from the working of the year 1887, the figures of which were now available, and had been adopted by him as the latest, notwithstanding that they were much less favourable to the chief metre-gauge line, the Rajputana, than those of 1886 adopted by the Author. The earnings of that line were nearly 20 per cent. greater per mile worked in 1886 than in 1887, and he might mention that, heavy as the traffic had been at times, in the former year, the pressure had been felt only on a section under 500 miles in length, less than one-third of the total mileage now worked. On that section the earnings had averaged Rs.414 for the first half of 1886, and for some weeks in May and June, during the busiest time, must have come up to Rs.650 per mile per week. Much had been said in the course of the discussion about comparing like with like in respect of capital cost. Might he ask for similar consideration in respect of working comparisons? In order to arrive at just conclusions from the figures of the Table, he would suggest attention, in the outset, to the figures on the lines numbered 2 to 7, 10, 12, 15, and 28, indicative of certain points, either of difference or of similarity, in the railways compared, and in their traffic; points quite independent of gauge, and which qualified, or otherwise, such conclusions. The relative, as well as absolute, dimensions of the several lines, and of their traffic, their age and gradients, and the price of fuel, all exercised either a direct or an indirect effect on carrying cost, irrespective of gauge. Gradients affected not only fuel consumption, but train-mileage, and with it the charges for locomotive and traffic running staff, which again were affected by train speed. As rates and fares varied, the traffic of each line was measured more accurately by work done (lines 10 and 12) than by money earned (line 7), and the ratio of coaching to goods traffic (line 15) ought not to be neglected. Further, the cost of gross ton-mileage, like that of train-mileage, could seldom be accepted as a measure of economical working, for as more trains might be run than were necessary, thus reducing the cost per train-mile by increasing the train-mileage, so might the gross ton-mile cost become delusive by exaggerated dead-weight hauled, due to excessive train-mileage, or

jor-General
lliams.

STATISTICS of WORKING of CERTAIN

Names of Railways grouped for comparison.		I. East Indian,[1] Great Indian Peninsula, and Bombay and Baroda.	II. Rajputana, S. Mahratta and Mysore, Tirhoot, South Indian and Bengal and N. West.	III. North Western, Madras and Oudh and Rohilkhand.
1. Gauge	Feet and Inches	5 6	3 3⅜	5 6
2. Mean age of railways compared, on 31st December, 1887	years	22·67	7·52	13·75
3. No. of railways grouped in each column		3	5	3
4. Mileage percentage of gradients worse than $\frac{1}{200}$		19	25	15
5. Mean mileage worked		3,687	3,764	3,745
6. Average mileage, per line of each group		1,229	753	1,248
7. Gross receipts per mile worked, per week	Rupees	520	147	184
8. Gross expenses per cent. of gross receipts	"	39·1	57·0	67·2
TON-MILES PER MILE WORKED.				
9. Gross		1,733,416	444,750	788,172
10. Coaching freight		38,651	16,245	18,571
11. Coaching, gross		451,129	154,847	273,003
12. Goods freight		527,108	107,983	164,567
13. Goods, gross		1,282,287	289,903	515,169
TON-MILEAGE PERCENTAGES.				
14. Total freight of gross ton-miles. . .		32·64	27·93	23·24
15. Coaching freight of total freight . .		6·83	13·08	10·14
16. Coaching freight of coaching gross. .		8·57	10·49	6·8
17. Goods freight of goods gross . . .		41·1	37·25	31·94
WORKING EXPENSES PER MILE WORKED.				
18. Coaching	Rupees	2,703	1,569	2,137
19. Goods	"	7,650	2,660	3,998
20. Total	"	10,353	4,229	6,135
COST OF TRANSPORT PER 1,000 TON-MILES.				
21. Gross	Rupees	6·0	9·5	7·8
22. Coaching and goods freight.	"	18·3	34·0	33·5
23. Coaching freight	"	69·3	96·6	114·9
24. Goods freight	"	14·5	24·6	24·3
AVERAGE COST OF HAULING FOR 1 MILE.				
25. One passenger unit	Pies[2]	..	..	..
26. One ton of goods	"	2·784	4·723	4·66
27. Locomotive and traffic running staff per 1,000 freight ton-miles.	Rupees	2·15	3·24	3·19
28. Average cost of fuel (in terms of coal) per ton	"	7·406	16·94	13·74
29. Fuel consumed per 1,000 gross ton-miles (in terms of coal)[3] .	lbs.	144·71 C., E.	184·0 A.C., E.W.	136·8 C., P., W.
AVERAGE RECEIPT PER MILE FROM				
30. One passenger unit	Pies	2·696	2·148	2·402
31. One ton of goods	"	7·036	7·787	6·365

[1] The figures for the East Indian Railway include the branches, &c., worked by it

[3] Fuel: A, Australian Coal; C, Country; E, English

Major-Gener Williams.

INDIAN RAILWAYS for the YEAR 1887.

IV. East Indian, Great Indian, Bombay and Baroda, North Western, Madras, and Oudh and Rohilkhand.	V. East Indian	VI. Great Indian Peninsula.	VII. Bombay and Baroda.	VIII. Rajputana.	IX. Madras, and Oudh and Rohilkhand.	X. Eastern Bengal Railways.	
			Worked by the same Agency.			Worked by same Agency.	
5 6	5 6	5 6	5 6	3 3⅜	5 6	5 6	3 3⅜ (mostly)
18·17	22·44	23·34	21·34	8·34	18·89	..	..
6	1	1	1	1	2	..	..
17	7	38	1·5	20	17	..	2·5
7,432	1,725	1,501	461	1,665	1,533	296	401
1,239	1,725	1,501	461	1,665	767	..	..
350	530	512	507	191	186	402	142
46·5	31·9	46·8	41·9	50·8	59·4	..	..
1,257,106	1,892,733	1,608,584	1,543,724	567,396	760,525	..	..
28,532	51,233	23,918	39,538	18,643	22,044	..	..
..	517,725	357,166	507,879	173,483	282,413	..	..
344,423	606,678	476,097	395,462	154,882	157,173	..	..
..	1,375,008	1,251,418	1,035,845	393,913	478,112	..	..
29·67	34·76	31·08	28·18	30·58	23·57	..	..
..	7·79	4·78	9·09	10·74	12·3	..	..
..	9·9	6·7	7·78	10·75	7·8	..	..
..	44·1	38·04	38·18	39·32	32·87	..	..
2,418	2,341	2,816	3,690	1,515	2,054	..	..
5,810	6,195	9,491	7,101	3,386	3,415	..	..
8,228	8,536	12,307	10,791	4,901	5,469	..	..
6·5	4·5	7·6	7·0	8·6	7·2	8·19	9·82
22·1	13·0	24·6	24·8	28·2	30·5	..	..
84·8	45·9	117·3	93·4	81·3	93·2	..	..
16·9	10·2	19·9	18·0	21·9	21·7	..	..
..	0·71	1·43	1·16	0·99	1·17	1·24	1·22
3·24	1·96	3·83	3·45	4·20	4·17	5·06	5·52
2·41	1·48	3·18	2·13	3·06	2·39	..	..
..	2·18	11·07	14·92	20·24	13·58	..	..
..	132·67 C.	184·75 Inf. C., E.	117·62 E.	157·87 Chfly. C. E.	140·2 C., P., W.	..	..
2·586	2·70	2·73	2·62	2·14	2·17	..	..
6.875	5·83	8·46	8·38	7·88	6·31	..	..

[2] One pie is about one-third of a farthing at present rate of exchange, namely, R.1 = 1s. 4½d.
P, Patent Fuel; W, Wood.

Major-General Williams. to badly designed rolling-stock. Having expressed this caution, he would invite attention, in the first instance, to the figures of the broad-gauge lines. The six most important lines were dealt with collectively in col. IV. For the three with really heavy traffic, and they were the oldest lines, the figures were shown separately in cols. V., VI., VII., and collectively in col. I. Then for the other three, the figures were given collectively in col. III. Again, two of the last three, namely, the Madras, and the Oudh and Rohilkhand, were grouped in col. IX. the North Western being excluded, so as to admit of fair comparison with the Rajputana metre-gauge line. Five metre-gauge lines had been taken, and their figures were grouped in col. II., whilst those of the most important of them, the Rajputana, were given separately in col. VIII. The Burma metre-gauge line had not been selected, as being out of India proper, and subject to special conditions of traffic and labour. The three Eastern Bengal metre-gauge lines had been avoided, because their statistics were mixed up with those of a line of still narrower gauge, two of the three were of very short length, and one was completely detached from the rest. It would be observed that, in grouping the lines, similarity in the mileage worked and in the gross receipts, or else in the work done, had been kept in view; but this could not be carried through with the group of metre-gauge lines, and to their disadvantage, the traffic of four out of the five being so insignificant. In fact, the traffic of only the Rajputana line came up, in 1887, to that of the inferior group of broad-gauge lines. Were the Rajputana line omitted from the metre-gauge group, the average earnings, per mile, per week, of the remaining four lines would be reduced to Rs.112, a figure which emphasized the notorious poverty of the traffic on which the secondary lines of railway, in general, had to depend, and the consequent necessity for limiting their first cost in every possible way. Yet it was said that the "donkey" should give place to the "elephant," with the certain result that the extension of railways would be restricted, and the travelling and trading public be deprived of the more frequent service only economically possible, when traffic was so very limited, with the smaller vehicle and train-units of a narrower gauge. Now for the comparison of results: The metre-gauge group, col. II., included five lines, so was burdened with the cost of two administrations more than either of the two broad-gauge groups of the same mileage in the columns flanking it. The traffic measured in earnings was only four-fifths, and measured in work done, only two-thirds that of the inferior broad-gauge group, col. III, and while rather more than

Major-Gener Williams.

one-fourth in earnings, was considerably less than one-fourth in work done than that of the superior group, col. I. Examine the figures of those three columns in lines 8, 16, 17, 22, 23, 24, and 26 (the passenger-unit had not been calculated). Notwithstanding the adverse figures of lines 27, 28, and 29, the cost of hauling 1 ton of goods for 1 mile, on the metre-gauge group, was almost identical with the cost on the inferior broad-gauge group, and only 2 pies per ton-mile in excess of the cost on the superior broad-gauge group. Of these 2 pies, 0·36 pie was due to price of fuel, and whilst (on Sir Bradford Leslie's scant allowance), the standing charges which were independent of the amount of the traffic, and consideration of which was entirely ignored by the Author, were only 0·42 pie on the broad-gauge group, they were 1·74 pie per goods ton-mile, on the metre-gauge group, or four times as much. With equality of traffic on the two, this difference would disappear. Thus, 1·68 pie was accounted for out of the total excess of 2 pies. Evidently this point need not be pursued, for granting a less capital outlay of Rs.15,000 per mile of metre-gauge railway (the actual difference from circumstances already referred to had been vastly more), and taking interest at 4 per cent., a saving per freight ton-mile of nearly 1 pie was realized on the existing traffic of the metre-gauge group. This again emphasized the paramount necessity of keeping down the capital account of railways having a prospect of only small traffic. Proceeding in a similar manner, it would be found that, charging fuel at the same rate on the metre-gauge group as on the inferior broad-gauge group, the cost of hauling 1 goods ton-mile was reduced to 4·59 pies against 4·66 pies on the broad-gauge group, and the former figure included 0·55 pie for standing charges, more than the latter, due to inequality of traffic. Next, he would draw attention to the figures in cols. V., VI., and VII., for the three heavy traffic broad-gauge lines separately. The differences in carrying-cost were quite as large as in the groups first dealt with, and suggested hesitation in drawing sweeping conclusions, be the gauge what it might. The East Indian Railway, with its good traffic (both up and down), light gradients and extremely cheap coal, dominated the entire railway system of India, and in comparison with it the figures for the Baroda line were especially noteworthy. The gradients (which were even more adverse than was shown by the figures in line 4), price of fuel, smallness of coaching traffic, and inequality of up and down goods traffic of the Great Indian Peninsula, must not be lost sight of. The anomaly in the figures of cost per 1,000 ton-miles on the two last named railways was

ajor-General illiams. apparent only. It was due to the different ratio of the coaching and goods traffic on the two lines. The Rajputana metre-gauge line (col. VIII.), need not shrink from comparison with any of these broad-gauge lines. The price of fuel accounted for 0·62 pie, and the standing charges for 1 pie of the excess cost per goods ton-mile (2·24 pies) of the Rajputana over that of the East Indian. He would now invite comparison of the figures for the Rajputana metre-gauge line with those for the two broad-gauge lines combined in col. IX., systems having much the same mileage, gradients, and amount of traffic, measured either in earnings or in freights, fuel being 50 per cent. dearer on the former. The Rajputana system, however, was less than half the age of the broad-gauge system, and the latter was weighted with the cost of two separate administrations, whilst the former shared that of the Baroda broad-gauge line. The broad-gauge system showed a great excess, about 200,000 ton-miles in dead-weight hauled, with this result, that the cost of transport per 1,000 gross ton-miles, was Rs.7·2 against Rs.8·6 on the metre-gauge system (line 21). This was not a result, he apprehended, which the Author would desire to quote in favour of the broad gauge in view of the figures in the next line (22). The coaching traffic (line 15) was larger on the broad-gauge group, due to the Madras Railway and its very low fares; but the ratio of paying load (line 16) was remarkably in favour of the metre-gauge line. The South Indian (metre) was in this respect even better than the Rajputana. The ratio of goods paying load was also much in favour of the metre-gauge line. Coming to carrying-cost per goods ton-mile (this was the crucial test, for the bulk of the traffic of Indian railways, see lines 10 and 12, was in goods), the metre-gauge line was apparently 0·03 pie to the bad; but equalizing the price of fuel, the carrying-cost was 3·97 pies on the metre-gauge line, against 4·17 pies on the broad-gauge group. In conclusion, he would ask the members to look at the following figures for two systems of combined broad and metre-gauge lines worked by the same agency (cols. VII. to X.). On the Eastern Bengal Railways, worked by the State, the mileage on the broad gauge amounted to 296, on the narrow gauge 401; while on the Baroda and Rajputana, worked by a company, the figures were, broad gauge 461, metre-gauge 1,665. One passenger unit was carried 1 mile on the Eastern Bengal, broad gauge, for 1·24 pie, on the narrow gauge for 1·22 pie; on the Baroda and Rajputana, broad gauge for 1·16 pie, narrow gauge, 0·99 pie. One ton of goods was carried 1 mile on the Eastern Bengal, broad gauge, for 5·06 pies, metre gauge, 5·52 pies; on the Baroda and

Rajputana, broad gauge for 3·45 pies, narrow gauge, 4·20 pies. And these results had been obtained, notwithstanding the small traffic, both comparatively and absolutely, of the metre-gauge lines; the gross earnings per mile per week being, on the Eastern Bengal broad gauge Rs.402, narrow gauge Rs.142; Baroda and Rajputana, broad gauge Rs.507, narrow gauge Rs.191. But whilst he claimed to have established his case as to the carrying-cost of the metre-gauge railways not being comparatively excessive, he wished it to be understood that in his estimation this was a secondary object. The greatest mileage of railways for a given outlay was India's need. The cost of transport in India was so much reduced by any railway, compared with that of the means of transport which it superseded, that the petty differences of working cost on which the Author, whether his figures were correct or incorrect, or whether he used them rightly or wrongly, rested his condemnation of the metre-gauge railways, were not worth consideration. The running, staff expenses and fuel consumption (lines 27 and 29 of the Table), of the narrow gauge might be a trifle higher than on the broad gauge, the maintenance expenses of the road and rolling-stock of all lines would increase with their age, but so would the traffic; and when the time came for renewals the young lines would follow the example of the old lines, and carry out betterments when and where really necessary, from revenue. Before, however, adopting the conclusion that the fuel consumption of the metre-gauge lines was materially greater, he recommended that the gradients and coal consumption of the Great Indian Peninsula (broad) railway should be examined in comparison with the other broad-gauge lines as well as with the metre group of col. II. of the Table. Of the fuel used on the Great Indian Peninsula Railway, 30 per cent. was from the Warora pit, the worst coal worked in India; but allowing for this large proportion of inferior fuel, the consumption per 1,000 gross ton-miles could not be put below 160 lbs., in comparison with other lines. So, also, before any increase of the section of rail in general use on the metre-gauge lines (steel, 41¼ lbs. to the yard) was decided on, the traffic should be considered most carefully. Up to the present time, such increase had not been demanded by the traffic on more than one-tenth of the entire system. The heaviest goods traffic, which it had been the good fortune of the metre gauge to be tried with, was over a section, less than 500 miles in length, of the Rajputana Railway in the first half of 1886, where it must have been throughout that half year at the rate of 400,000 freight ton-miles, per mile worked, per annum, and for a few weeks 50 per

Major-Gene Williams.

jor-General lliams. cent. in excess of that. The significance of that traffic would be understood by inspection of the figures in line 12 of the Table. Yet a line which had carried such a traffic as this, was a "toy!" He admitted that it was a donkey, and a very fine donkey, too. The Indian Government, having learnt from experience the lesson of adapting means to ends, ought to resist all outlay for the accommodation of traffic, neither existent nor probable, the outlay on works carried out, twenty to thirty years ago, on the older broad-gauge lines, in too sanguine anticipation of the necessity of doubling their track (not even yet done on more than 1,000 miles of their length), having proved with that exception totally unproductive, and been at least trebled in amount by interest. It had been argued that for a maximum traffic the broad gauge admitted of the more efficient machine. This might be true of a traffic in excess of the power of the metre gauge, but to put this question on a pseudo-scientific basis of that kind was unpractical, inasmuch as it ignored the environment of all questions of railway extension. Responsible military authority alone was justified in pressing for the most efficient and powerful railway machine, irrespective of the ordinary commercial traffic expected, or the immediate money outlay, and failing to secure that, would be too wise to reject a less powerful machine. The facts and figures adduced by the Author had led him to adopt, as "almost logical conclusions" therefrom, the opinion that broad-gauge railways were as cheap both to construct and work as metre-gauge lines, and that future extensions ought, therefore, to be made on the broad gauge; but the facts and figures, when dealt with in a logical manner, established the very contrary.

. Atkinson. Mr. W. ATKINSON asked to be allowed to make an explanation. Since stating that all the figures given in the Table of means were erroneous, he had looked at the Administration Report, and taken out the figures to prove his statement. He would give an example that would clearly show the error that had been made. Supposing a line had cost £1,000, and earned 5 per cent., and another had cost £100, and earned 1 per cent., the Author had added the 5 to the 1, and divided by 2, giving 3 as the mean earnings of the two railways. Of course the mean would be $50 + 1 \div 11 = 4 \cdot 65$. No argument could therefore be founded upon any of the mean figures given in the Table. In order to be quite certain, he had taken out the figures for the first three items on p. 38. In regard to the capital outlay per mile open for the eight railways taken, the mean of the broad gauge was stated to be Rs.168,100. Mr. Atkinson made it Rs.174,500. Deducting the one from the other,

and multiplying by the number of miles, there was a total excess of nearly Rs.49,000,000. He had not worked out the figures for the narrow gauge. The mean of the percentage of the net earnings should be 6·300 instead of 5·185, making a difference of 1·115; or multiplying that by Rs.13,388,500, an excess of Rs.14,945,520. The earnings per mile open per week should be Rs.375 as against Rs.346·5; 28·5 multiplied by fifty-two weeks on 7,647·8 miles, gave a difference of 11,334,040. It would have been an improvement if the Author had given, in addition to the means of the metre gauge, on p. 39, a statement of each divided by the corresponding 5 feet 6 inches mean, then the result would have shown at a glance the amount of each item, that on the 5 feet 6 inches being unity, and thus the cumbersome expression of the capital outlay on the 5 feet 6 inches gauge being 168 per cent. more than on the metre gauge would have been avoided. If the Author's figures were correct, the capital outlay thus expressed on the metre gauge would be 0·363, and the total earnings per mile per week would be 0·37, showing that the construction and earnings accounts were just in proportion on the two gauges. Then the net earnings would be 0·75 as against 1, showing a deficiency of 0·25. Mr. Atki

Mr. J. R. Mosse said he had not gone into the figures to which Mr. Atkinson had referred; but he thought the Author had acted fairly in comparing the 95 per cent. of the total mileage on the broad gauge, with the 86 per cent. on the narrow gauge, doing the best he could with the returns. The Author would no doubt be able to deal with the figures when they were submitted to him, as he was always most painstaking and accurate. The comparison showed the great disadvantage under which the broad gauge had laboured. General Williams had himself admitted the difference in the circumstances under which the two lines had been made. There could be no doubt that the broad gauge could now be made for 30 or 40 per cent. less than the original cost. But it was really not a question of gauge at all; it was a question of the quality of the line. If the rails, stations, and railway-stock were the same in both cases, the difference would be next to nothing. The report of Sir G. Molesworth, presented some years ago to the Government of India, was that a broad-gauge line, made equivalent to the rolling-stock of the guaranteed railways, would cost £1,600 or £2,000 per mile more than a narrow-gauge line. "The cost of a broad-gauge railway," he said (45-lb. rails), with structures designed only for the carriage and wagon stock of the guaranteed railways, but not for the engines, will exceed the cost of a narrow-gauge line by £720 or £1,000 per mile. The cost of a Mr. Mos

Mr. Mosse. broad-gauge railway (40-lb. rails), with structures designed for the same axle loads as the narrow gauge, will exceed the cost of a narrow-gauge railway by £350, or £500 per mile." That was the extent of the saving, if both railways were made of the same class. The same result would be found in the second report of the Royal Commission on Irish Public Works, published only last year; the difference, obtained from detached estimates made for 202 miles of light railways, being there given at about £500 per mile, as between the 3-foot gauge and the 5 feet 3 inches. It was also stated that the extra cost of the rolling-stock, which would be necessitated by the change of gauge, would nearly extinguish the saving effected by the narrow gauge. General Williams was of course right in saying that no accurate comparison could be instituted unless two railways were made on the same ground, and under the same conditions; but the Author, having taken the official returns as he found them, had, he submitted, made a fair comparison. He had worked out this result on the same system in both cases; and if there was any error in the one case, a similar error would be found in the other. He differed from Mr. Shelford, in regard to the economical working of the metre gauge, and also in regard to the result of train-mileage being the material point, which was contrary to his experience. It cost nearly the same to run an empty train as it did to run a full train, the majority of the charges being constant, whether the train was full or empty. The crucial point was the passenger-unit, and the ton-unit. General Williams had advocated the narrow gauge, but in reality the items 11, 12, and 13 were thoroughly against him. They showed that the cost of transport per 1,000 gross ton-miles, on the Great Indian Peninsula, was Rs.6, on the Mahratta Rs.9·5, on the East Indian Rs.4·5, and on the Rajputana, Rs.8·6. Of course the grades must come in, and a variety of other circumstances; but he thought it would be difficult to prove that the metre gauge could be worked more economically than the broad gauge. Item No. 17 in the Paper showed that the average freight-weight of a coaching train was 16·018 tons on the broad gauge, and 13·563 tons on the metre gauge; in other words, the average freight-weight on the broad gauge was 18 per cent. more than on the narrow gauge. In the case of a goods train the figures were more favourable to the broad gauge, the average freight-weight being 128·675 tons, while on the narrow gauge it was 66·587 tons, little more than a half. The average cost of hauling a passenger-unit 1 mile on the broad gauge was 1·123 pie, and on the metre gauge 1·37 pie, or 18 per cent. in

favour of the broad gauge. The average cost of hauling a goods unit 1 mile was 3·93 pies, and on the metre gauge 6·036 pies, being 53 per cent. in favour of the broad gauge. Taking the ordinary percentage of working expenses to receipts, it was 50·826 on the broad gauge, and 63·22 on the narrow gauge. But without accepting the Author's figures, he was quite content with those given by General Williams. He had had some experience in Canada, and was familiar with various railways that had been constructed on the 5 feet 6 inches gauge. For several years attempts were made to alter that gauge to the 4 feet 8½ inches gauge of the United States. All sorts of plans were designed to meet the necessities of the case. Freight bodies were transformed to freight frames suited to the 4 feet 8½ inches gauge, the wheels had tires 5 or 6 inches wide, and other arrangements were made in order to avoid the necessity of an alteration in the gauge; but in the end the change had to be made. On the Grand Trunk Railway in Canada, the Inter-colonial Railway between Halifax and Quebec, and the Great Western Railway of Canada, the mileage was about 2,500, and the whole of it had to be altered to 4 feet 8½ inches for the sake of uniformity with the railways of the United States. It would be readily understood that only dire necessity would have led to the expenditure of so large an amount as was necessary to alter the rolling-stock for such a mileage. Any line of railway could be made cheaply irrespective of gauge; but a good railway, like the guaranteed railways in India, should not be compared with the inferior railways of the metre gauge. They were different in quality in every respect; and if the Indian Government wanted to prevent the rolling-stock of the guaranteed lines from ever coming upon a light railway, a very effectual mode of doing it had been adopted. Whether or not the change of gauge would compensate for the inconvenience which might arise was a question which he could not decide. The general opinion of those who entered into the question, many years ago, was that the break of gauge was a national evil, and a similar opinion had been expressed by the Commissioners on the Irish Public Works. As Director of Public Works in Ceylon he had assisted in preventing a break of gauge in a colony where it would have been peculiarly unfortunate, the railway going over 5,000 to 6,000 feet elevation with a large traffic requiring very heavy engines, heavy rails, and everything else on a first-class scale. Mr. Mosse.

Mr. S. J. Wilde said that, as a Director of the Bombay and Baroda Railway almost from the commencement, he was of opinion that sufficient allowance had not been made for the great cost of the Mr. Wilde.

Wilde. original guaranteed lines in India. General Williams had alluded to the fact of the Government having compelled that company to begin the railway in the middle at Surat. It was thought that the rapid river Nerbudda, with a great rise in the monsoon period, could be crossed with safety, but a small arm of the sea near Bombay could not be crossed although the water was calm, and the works were commenced at Surat. Worse still, it was necessary to work backwards to Bombay, and that at a period when freight was very dear; the cost of carrying the material from Bombay to Surat being as great as the cost of the transport from England to Bombay, and then it had to be brought back towards Bombay. That made a great difference in the cost of the line. Moreover there was a great loss during the Mutiny. The works were stopped by the Government, and though orders were given to go on again, there was a direct loss during the season of £30,000 or £40,000 on that line independent of indirect losses. Any comparison, therefore, of the old guaranteed lines with the modern lines was very fallacious. The comparisons made by General Williams between the Rajputana line on the one side, and the Madras and Oude and Rohilkhand on the other, were not correct; because, although the figures were very similar, the Rajputana was a single system, worked to a great extent with through trains and through-train loads, while the others were two different systems unconnected with one another; therefore the cost of working the latter must be much more. He believed also that neither the Madras nor the Oude and Rohilkhand was working up to the full extent of its mileage, while the Rajputana had nearly arrived at its maximum. On certain portions of the line in certain seasons the traffic could hardly be carried at all, and permission had been sought from the Government to allow the construction of relief lines. Of course, where the line was worked up to its maximum, it could be worked more economically than where it only carried a small portion of its possible traffic. Lately the Bombay and Baroda Railway Company had wished to make a line on the narrow gauge, being an extension of its own line from Delhi to Kalka. The Government, however, had refused, because it wanted the broad gauge. Of course, a piece of broad gauge at the end of a narrow gauge would be of no use, and the line had been given to another company. If rumour was correct, he believed that some of the gentlemen who were most influential in introducing the narrow gauge into India, in the first instance, had voted against the Company in the Council. The line from Baroda to Ahmedabad was 300 miles long, and upon that line there were 7 miles of

bridges, which, of course, had added enormously to the cost of construction. Mr. Wild

Mr. W. Wiseman considered that the Author had placed before the members some very useful facts and figures. So many opinions had been expressed on the gauge question, that it was quite a pleasure to know that at last there were some facts and figures for discussion. There were, however, a few figures which in their present shape could not, he thought, be considered to be complete for the purposes of comparison of the working results and merits of the two gauges. He thought the Author was not quite right when he said that the facts submitted in the Paper would test the soundness of the views expressed on both sides of the gauge question. Take, for example, fuel consumption. The Author had stated that "the average consumption" of fuel "per 1,000 gross ton-miles shows an economy of more than 26 per cent. in favour of the broad gauge." He thought the Author would have been more correct if he had said that it showed a difference and not an economy in favour of the broad gauge. If all the lines were on a dead level, and straight, the economy would, no doubt, be in favour of the broad gauge, but as no two lines were alike in their gradients and curves, it was quite a matter of chance if the economy of 26 per cent. in favour of the broad gauge were correct. It might be a great deal more or a great deal less. There were railways in India remarkable for high grades and numerous curves; and there were others remarkable for low grades and absence of curves. It was evident that if two narrow-gauge lines or two broad-gauge lines were selected as representatives of those different conditions, and the working expenses were so drawn up that they could be apportioned in a proper manner over the curves, gradients and levels, the figures so obtained would have a definite meaning, and would be very valuable, as a fair comparison of the two lines could then be made under the various heads which fell under "working expenses;" and if one of those lines, say one with high grades and numerous curves, was on the narrow gauge, and the flat line on the broad gauge, and the working expenses were apportioned in the same way, the resulting figures would be still more valuable, as the merits of the two gauges, so far as working expenses were concerned, would be established on a correct basis. It had been ascertained in America that an average of about 7 per cent. of the total cost of engine repairs was due to curvature. In a similar manner if the managers of each line of railway would by a few simple experiments ascertain how the expenditure under the sub-heads of "working expenses" was affected by its curves

iseman. and gradients, and would publish the results, it would not only be easier to compare the relative working merits of narrow and broad-gauge lines, but of all lines of the same gauge, one with another. The figures would also show whether the lines were being economically worked or otherwise; and he should not be surprised if they proved that the best or most economical class of engines was not used in all cases. Although some of the figures in the Paper were open to criticism, it was a valuable one, and Mr. Wiseman joined in thanking the Author for presenting it to the Institution.

lumper. Mr. A. W. SZLUMPER exhibited a map, with a view of showing that the broad-gauge lines in India were really all the trunk lines. It would, he said, be seen that all the large towns and places of importance were connected by lines on the 5 feet 6 inches gauge, while the metre-gauge lines were chiefly small lines acting as feeders to the broad-gauge railways. Very few of the metre-gauge lines, with the exception of the Rajputana, were worked up to their capabilities. The South Mahratta system, over 700 miles in length, only returned $1\frac{3}{4}$ per cent. on the capital outlay. The Author had omitted to refer to the great difference between Indian railways and those in England. In India there were military considerations to be borne in mind, and railways had to be constructed for famine-preventive purposes; so that the commercial aspect of the question was absent in great measure; hence it was hardly fair to compare the Indian lines with English or Colonial railways. It would appear, from the results of working, that the Government was justified in having adopted the metre gauge in India.

r. Barry. Mr. J. WOLFE BARRY remarked that it had been lately his lot to investigate the subject of railway gauge with some considerable care, in conjunction with his colleagues on the Royal Commission on Irish Public Works. The matter had been debated with a great amount of heat in Ireland, as it had been in England and in India, and indeed everywhere, since the battle of the gauges between the Great Western Railway and the narrow-gauge system in this country. Some years ago the Lord Lieutenant of Ireland, led away by an idea of the advantages of narrow-gauge lines, had put a premium upon the promotion of those lines rather than of light railways of the Irish standard gauge. The inducement offered was that the Government would guarantee a percentage upon the cost of the narrow-gauge lines, but that any additional cost of light broad-gauge lines would have to be paid by the promoters out of their own pockets. Accordingly some lines had been made in Ireland on the 3 feet gauge. The circumstances connected with

those railways had been investigated with great care, and the result of the investigation was contained in the second report of the Commissioners.[1] It was found, after careful estimates made by experienced engineers, that the extra cost of about ten contemplated lines of a total length of 202 miles, if made on the Irish gauge, would vary from £300 to £500 per mile. Some portions of those lines were in mountainous districts, where curves were of importance as materially affecting the first cost of construction. But allowing for such circumstances, the Commissioners came to the conclusion that the Government might safely take it that a broad-gauge line would not cost more than £500 per mile in excess of one of the narrow gauge, assuming that the weight to be carried on the engine wheels was the same in both cases—in fact comparing like with like. It was necessary to remember, when comparing like with like, in regard to the weight of the rails and general construction, that the limiting matter to be considered was the weight on the engine wheels, and not on those of the carriages and wagons. The Government had settled what was to be the limiting weight on the engine wheels in Ireland, in the case of all light railways of either gauge, and that limit was adopted by the Commissioners as a standard of comparison in the two cases. The quantity of rolling-stock necessary, where a break of gauge occurred, had to be thus so estimated, that the maximum amount of rolling-stock must be taken for each section of the line; so that in the case of a short branch line there should be such an amount of rolling-stock as would deal with the maximum traffic, and not merely with the average traffic. Rolling-stock could not, owing to the difference of gauge, be drawn from other portions of the railway to deal with exceptional circumstances, and it was therefore obvious, in the case of short lines, that an unnecessarily large amount of rolling-stock must be provided on lines isolated by break of gauge, and this fact was a considerable set-off against any increase of cost of construction. In Ireland the lines were short, and therefore, perhaps, speaking generally, any comparison with the lines in India was not quite appropriate. But it should be remembered that it was very difficult to foresee the future of a railway. It could not always be a matter of certainty that a new railway, even in India, would always start from the point of production and finish at the port of export, though it might be designed to do so. Such might be the case for a year or two, but in a short time circum- Mr. Barry

[1] Second Report of the Royal Commission on Irish Public Works, 1888, p. 30 *et seq.*

Barry. stances might alter, and it might have to be considered how the traffic was to be sent over other railways. Then, even in the case of long lines, the question arose of a break of gauge, and the weight of evidence in England, in the United States, and in Canada, was so enormously against any break of gauge, that any one proposing it ought to be able to show some great and overwhelming advantage in cost of construction or working. Even with regard to India, he thought that the Table submitted by General Williams, so far from showing any advantage for the narrow gauge, would only, even strained to the utmost, bring it up to something like an equality in cost of working some descriptions of traffic. When the subject was discussed, many years ago, in that room, with great energy on both sides, a former Governor-General of India expressed his belief that a break of gauge was rather an advantage from a military point of view, because at some particular places troops had to be landed and refreshed, and it was therefore a good thing that there should be some points at which the process was obligatory.[1] It did not appear to have occurred to the speaker in question that it was possible that they might be landed and refreshed without any break of gauge. To show, on the other hand, what a break of gauge really meant, he might mention that one of his colleagues on the Royal Commission on Irish Public Works was Sir James Allport, who had been all through the battle of the gauges, and his recollection, which was corroborated by that of other experienced railway managers, was that, in the division of through rates for goods passing from one gauge to another, 30 miles were credited to the company that undertook the expenses of the transfer from one gauge to the other. That certainly seemed a very startling thing. If all that had been gone through in England, with the result that the Great Western Railway Company had almost entirely rejected the broad gauge, and if in Ireland the testimony was almost overwhelming against a break of gauge (some gentlemen who had made narrow-gauge lines saying that they were sorry for it), he thought that the case against these narrow-gauge lines was thoroughly established. He hoped that if people wanted a cheap line they would still make it on the existing gauge. They were surely strong enough to resist the seductions of civil engineers, who were supposed to want to make an expensive line. Let engineers at any rate have the courage of their opinions, and if a cheap line was wanted do as contractors did, who, when they

[1] Minutes of Proceedings Inst. C.E., vol. xxxv. p. 325.

wanted to make an overland route, to last merely a year or two, did not make a break of gauge in order to save a few hundred pounds per mile, but always adopted the standard gauge so as to convey all the goods required for construction without transhipment. Let the public be content with a light railway of the standard gauge, and be content also with low speeds, thus not attempting to send over the railway heavy engines which were suitable for other parts of the line. Under those circumstances all supposed economies connected with narrow-gauge lines would vanish, and a great advantage would be gained in the development of traffic and in saving of working expenses, looking at the railway as a whole, and not cutting the traffic up into fanciful divisions. Mr. Barry.

Mr. W. SILVER HALL said it would be interesting to know whether, when the railway gauge was altered in Canada, there was any notable increase or decrease in the cost of working. Mr. Hall.

Mr. WILLIAM LAWFORD heartily concurred in all that had fallen from Mr. Barry as to the evils of a break of gauge. His experience on that point had begun very early, almost half a century ago, when Mr. Robert Stephenson requested the Directors of the then Eastern Counties Railway and of the Northern and Eastern, which had since become the Great Eastern Railway, to alter their gauge. The line was originally laid out on a gauge of 5 feet 6 inches, but it was constructed on a 5 feet gauge as far as Colchester on the one hand, and as far as Bishop's Stortford on the other. In 1843 Mr. Stephenson saw the great difficulty that must necessarily arise from a break of gauge in connection with the Eastern Counties district, and he persuaded the Directors to have the line altered. The consequence was that in 1844, the 50 miles from Colchester to London, and the 30 miles from Bishop's Stortford to Stratford, were changed to the 4 feet 8½ inches gauge, and the rolling-stock was altered at the same time. It was much to the credit of the two engineers who undertook the work, Mr. W. P. Marshall and Mr. George Berkley, that the whole thing was done in one month without a single accident; and the traffic, which was a large one for those days, was going on at the same time. The actual cost of altering those 80 miles, including the alteration of the rolling-stock, was £44,000, or about £550 per mile. His next experience was in 1863, when the West London Extension Railway was opened; of which 4½ miles, constituting the main line, was made upon what was called the mixed-gauge principle, 7 feet and 4 feet 8½ inches; but after the line was opened the broad gauge was never used for passenger traffic, except that on one occasion a troop of soldiers was sent over it from Victoria to Windsor; there Mr. Lawford.

Lawford. was also a certain amount of coal and mineral traffic from the Addison Road Station to the Chelsea Dock, but nothing more. In 1873 the broad gauge was entirely removed. The extra cost (which fell upon the Great Western Railway Company) of making the line available for the two gauges was £27,300. In 1872 the whole of the South Wales Railway (202 miles of double line), originally constructed on the broad gauge, was taken up and altered to the 4 feet 8½ inches gauge, in between four and five weeks, without accident, at an expense of about £100,000; which sum included the necessary alterations to sidings, cross-over roads, the extending and raising of platforms, &c.

Frederick Bramwell. Sir FREDERICK BRAMWELL said that, since reference had been made to Mr. W. P. Marshall as having been engaged in the alteration of gauge on the Great Eastern and on the Northern and Eastern Railways, he might be permitted to quote that gentlemen's experience in Canada as to one of the modes in which the difficulty of a break of gauge was met. It was extremely original and unusual, and he thought that the members of the Institution ought to know of it. The axles of the carriages and of the wagons were made with the wheels loose upon them, so that they could slide endways. They were held in position on the axles by cross-cotters—whether in the nature of garters or through cotters he did not remember. On coming to a break of gauge, the necessary change in the position of the wheels on the axle was effected by drawing the train along a conical line leading from the broad to the narrow gauge. The keys being out of the wheels, these went sliding along on the axles; and when they were driven into the narrowed position the keys were reinserted, but in other key-ways, and the train went gaily along the narrow-gauge line.

Sir George Bruce. Sir GEORGE B. BRUCE, President, observed, in the absence of the Author, that although the figures in the Paper had been to some extent criticized by Mr. Atkinson and others, he was disposed to think that the general results were not very far wrong, though the mean might not have been taken quite accurately. They did not appear to differ very much from those given by General Williams, with regard to the cost of haulage upon the narrow as compared with the broad gauge. Mr. Shelford had said a great deal with reference to the Author having taken the ton-unit and the passenger-unit as the measure of the efficiency of a line, and he had stated that he thought it was better to adopt the ordinary English plan of working by the train-mile. It was perfectly true that in England, where the railways were much alike, as well as the weight of the engines and the load, the train-

mile was a very convenient general standard of comparison; but it was quite out of the question where goods trains upon one system were three times as heavy as upon another; in such cases the train-mile standard was worthless, but the ton-unit and the passenger-unit gave a proper and accurate comparison. General Williams had drawn attention to the fact that the broad gauge had cost a great deal more than the narrow gauge; and he had attributed it, partially, at all events, to the want of experience of the early engineers who were engaged in India. Sir George Bruce was one of those early engineers, and he of course pleaded want of experience of the country, as was the case with every man who went there for the first time. But he did not think that any mistakes worthy of the name were made. Looking back over a period of thirty years, he did not know that anything had been done by himself, and other engineers, which would be reversed even if they had had much more local experience. The first section of the Madras Railway was opened thirty-two years ago for about £6,000 per mile, with its broad gauge, heavy rails, and so on, and he did not think, with any amount of experience, they could have done better than that. The greater part of the earthwork upon that section was executed for a little over 1*d.* per cubic yard. The bridges, some of which were over wide rivers, and built of coursed granite (the new-fangled iron bridges had not then been adopted) were completed for about Rs.3½ per cubic yard, equal to 7*s.*, including masonry arches, piers, and everything, and he did not know that any amount of experience could have cheapened that. At the discussion, sixteen years ago, he estimated the difference of making the South Indian Railway broad gauge or narrow gauge (in so far as the cost depended on the gauge) at £200 per mile; and Mr. Barry had stated that in Ireland the difference was estimated to vary from £300 to £500. Sir George Bruce adhered to his statement that £200 per mile was the real difference due to the gauge. The broad-gauge portion of the South Indian Railway, 168 miles, was built for about £7,700 per mile; the narrow-gauge portion for about £6,400. The difference there was a great deal more than £200 a mile; but how did that arise? From the fact that in one case 68-lb. rails were used, and in the other 40-lb. rails, and other things in like proportion. One fact that made the broad-gauge lines cost more than the narrow-gauge was that they carried three times the amount of traffic, and therefore required much more extensive sidings, a larger amount of rolling-stock, and greater accommodation in stations and workshops, enhancing the cost considerably. But the only saving due to gauge was £200 per

Sir George Bruce.

Sir George Bruce. mile; and the simple question was whether it was worth making the break of gauge in India for the sake of such a saving. If the course had been followed to which Mr. Barry had drawn attention, and which was advocated in that room sixteen years ago, of keeping the gauge uniform and adopting light rails, and laying down heavier ones if and when the traffic required it, uniformity of gauge would have been maintained with an additional expenditure of only £200 a mile. He was surprised that Mr. Giles approved of the Government of India adopting cheap narrow-gauge railways. That was simply begging the question, because the question was whether the lines were cheap. Mr. Giles suggested that it was the right thing to lay down the 3 feet 3 inches gauge, and afterwards take it up and lay down a broad gauge; but that would upset everything, as the bridges and other works would have to be rebuilt when the gauge was altered, and all the rolling-stock would be useless. £200 per mile would be saved, but then some thousands would have to be spent afterwards in alterations.

Mr. Giles. Mr. GILES said that the argument had gone upon the assumption that the rails for the metre gauge were to be as heavy as the rails for the broad gauge; he had assumed that the metre-gauge lines would be made of very much lighter material in every respect than the broad-gauge lines.

Sir George Bruce. Sir GEORGE B. BRUCE, President, said he was rather dealing with the question of the difficulty of altering the gauge. It would be far easier to make a line heavier if the same gauge were maintained than it would be if the gauge had to be altered. The members were much indebted to the Author for his Paper. An opportunity would be afforded him to reply in writing to the observations that had been made during the discussion. They were also much indebted to General Williams for attending and explaining so fully his views upon the subject, and although some of them might differ from him as to the wisdom of the course the Government had pursued, they were all glad to hear the expression of his opinions.

Mr. Waring. Mr. F. J. WARING, in reply to the discussion, remarked that several of the speakers seemed to imagine that he had exercised some selection of the railways, the statistics of which he had dealt with. He begged to state that this was not the case, but that, on the contrary, he had taken, in framing Table IV, all the lines, both broad and narrow gauge, the detailed statistics of which were given in the Administration Report, the aggregate length of which comprised 90 per cent. of the total mileage open for traffic. He thought that by taking this comprehensive view of the matter, such questions as the physical conditions, summits, gradients and

curves, could be safely left out of consideration, as neither system could be assumed to have a monopoly of disadvantages in these respects; of course, had one particular line of 5 feet 6 inches gauge been compared with one particular line of the metre gauge, these points would have had a very important bearing on the cost of working, and could not have been ignored in dealing with the question. If, however, the view he had just expressed were not accepted, he thought that, at any rate so far as gradients were concerned, an examination of the following Table would show that in respect to all the railways, the statistics of which had been dealt with in Table IV, there was not a great difference between them. Mr. Waring.

AGGREGATE LENGTH OF STEEPEST GRADIENTS.

Gradient.	5 feet 6 inches.		Metre gauge.	
	Mean Mileage worked in 1886.	Percentage of total length.	Mean Mileage worked in 1886.	Percentage of total length.
$\frac{1}{50}$ or less.	30·75	0·402	3·40	0·078
$\frac{1}{51}$ to $\frac{1}{80}$.	62·94	0·822	50·70	1·146
$\frac{1}{81}$ to $\frac{1}{100}$.	220·75	2·886	188·35	4·260
$\frac{1}{101}$ to $\frac{1}{200}$.	970·17	12·678	598·27	13·532
$\frac{1}{201}$ to $\frac{1}{300}$.	540·49	7·067	415·37	9·395
Totals . .	1,825·10	23·855	1,256·09	28·411

The steepest gradient on any line of 5 feet 6 inches gauge was 1 in 37 on the Great Indian Peninsula Railway, its greatest continuous length being 5·85 miles; while the steepest gradient on any metre-gauge line was 1 in 40, on the Rajputana-Malwa line, its greatest continuous length being 3·40 miles. As regarded curves, the Administration Reports contained no data enabling him to make a similar comparison; but as far as could be judged from the particulars given in Table I, referred to in the Paper, the metre-gauge lines presented no example of an unusually sharp radius having been adopted on them. He had also been criticised for contrasting trunk or arterial lines of railways with subsidiary or feeder lines, and for, when framing Table IV, not taking into account the items of length, traffic, cost, &c., of the lines thus contrasted. His answer to the first criticism was that it was no fault of his that the Government of India, by generally making, or

Mr. Waring. allowing to be made, the trunk or arterial lines of railway on one gauge, and the subsidiary lines upon another, had rendered any course other than that which he had adopted impossible. In reply to the second line of criticism that had been adopted, he might state that when preparing the Paper the point had occurred to him, but that upon consideration he had thought it preferable merely to present to the Institution the figures as collated from the Reports, and the means derived from them, leaving the figures to speak for themselves, and to serve as a basis for discussion, rather than by introducing other figures or calculations of his own into the matter, in any way to justify the view that he had approached the question with a bias in favour of either gauge. Upon this point he thought he might be permitted to refer to the concluding paragraphs of the Paper itself. It had afforded him much gratification to learn that Sir Bradford Leslie, whose long and varied Indian experience constituted him one of the best authorities upon the question, so thoroughly concurred as to the causes which had led to the higher cost of construction of the broad-gauge lines as compared with those on the metre gauge generally. He was also perfectly in accord with Sir Bradford Leslie as to the important bearing which the age of a line had upon the cost of its maintenance, as well as with his views as to the influence which the inferior type of engine, necessarily used upon the metre-gauge lines, had upon the present cost of working them, and the much greater influence this inferiority of locomotive might be expected to exert in the not remote future. If Mr. Shelford would permit him to add the words "as influencing the cost of construction," to his statement that, "of all things which constituted a railway the gauge was perhaps the least important," he thought that upon that point their views would be identical. Mr. Waring had specially limited his advocacy of the "ton-mile," in preference to the "train-mile," as being the proper basis of comparison, to the case of railways differing so widely in almost every condition from each other, as the Indian lines now under consideration did; and he certainly could not agree with Mr. Shelford that, in dealing with such lines, a comparison based upon "train-mile" results would have any practical value. In this view he thought the majority of the meeting agreed with him, as well as the Government of India, who so largely used the "ton-mile" in the statistics given in the Reports. Holding it so strongly as he did, he did not think it necessary to follow Mr. Shelford into his remarks as to the superior economy of working metre-gauge lines in certain respects when measured by the "train-mile" standard. Mr. Waring

emphatically disclaimed any advocacy of the 5 feet 6 inches gauge Mr. Waring in itself; in fact, he considered that experience had now amply shown that the 4 feet 8½ inches gauge was quite enough for dealing with almost any amount of traffic; but, having at the outset introduced the 5 feet 6 inches gauge into India, he concurred, with Mr. Lewis and Mr. Wolfe Barry, that it would have been far better policy had the Indian Government adhered to that gauge throughout the country, constructing the subsidiary or feeder lines upon it, but laying on them a lighter permanent way, and equipping them with correspondingly lighter and less powerful engines, travelling necessarily at lower speeds than upon the trunk lines. In this way he believed the feeder lines would at the outset be, in accordance with Mr. Shelford's views, well suited to the country, and would equally with the metre-gauge lines be sooner worked up to their full carrying capacity than the heavier type of railway adopted for the trunk lines, while all break of gauge would have been avoided. He considered, moreover, that the statistics adduced had shown that, apart from break of gauge, the railways upon the metre gauge were too limited in their carrying capacity, and possessed other disqualifications which rendered them unequal to deal to the best advantage with even the limited amount of traffic that they had secured. He had to tender his thanks to General Williams for pointing out so many conditions, not referred to in the Paper, which had adversely influenced the cost of construction of the earlier railways upon the 5 feet 6 inches gauge; he thought, however, and upon this point he much regretted to have to differ from General Williams, whose great experience upon Indian railways entitled anything he said upon the subject to be received with every consideration, that if to the points referred to by that officer were added those mentioned in the Paper, much, if not the whole, of the increased cost of the earlier broad-gauge lines, as compared with those of the metre gauge, would be fully accounted for. But with regard to the more recently constructed lines on both gauges, where the difference of cost was not generally so great, he still believed that this difference could be fully accounted for by the difference in class of railway made, and by the other altered conditions referred to in the Paper. Not having had access to the Administration Report for 1887, out of which he understood General Williams had compiled his Table, Mr. Waring was unable to follow him into details of the figures given in it; this had been done by Mr. Mosse, with whose conclusions he thoroughly concurred. He was somewhat surprised that the little Patri Railway, a line of 5 feet 6 inches gauge, had not been referred to in the

Mr. Waring. discussion. The cost of that line was only Rs.35,929 per mile; of course, it having been made, and being worked by the Bombay, Baroda and Central India Railway, it was not burdened with the cost of administration, &c., to the same extent as it would have been had it been made by a separate and independent company. This line, however, appeared to be, the rails weighing only 48 lbs. per lineal yard, the solitary example of a light railway upon the 5 feet 6 inches gauge in India, and it was specially upon that account that he directed attention to it. Finally, as examples of the economical construction of lines upon the 5 feet 6 inches gauge, he might quote the open portion of the Indian Midland, laid with rails weighing 75 lbs. per yard, which had cost Rs.67,566 per mile, and the Khamgaon branch of the Berar Railway, laid with 60-lb. rails, and which had cost Rs.60,321 per mile, as well as the Dildárnagar Gházipur Railway, laid with steel rails weighing 62 lbs. per lineal yard, which had cost Rs.58,588 per mile. All these lines were comparatively remote from the sea coast, and he thought that their cost compared very favourably with that of some of the metre-gauge lines quoted by General Williams, especially when the class of permanent way upon each was taken into consideration.

Correspondence.

Mr. Hart. Mr. J. H. E. Hart referred to a paragraph in a recent number of the "Homeward Mail":—"Sir Guildford Molesworth and Colonel Smith report, as the result of their reconnaissance of the East Coast, that a railway communication between Bezwada and Cuttack can be secured at a moderate cost, including the bridging of the Kistna and Mahanadi rivers. A line of 507 miles would cost 482 lacs for broad gauge, and 307 lacs for metre gauge." This estimate made the ratio of cost as 3 to 2 nearly, and showed a mileage excess of about £3,450 (Rs.95,000–60,500). To any one who had seen the difference of the finish of the works on the two systems, the comparison drawn would have but little value. When the narrow-gauge lines had been in existence as long as some of the broad-gauge lines, their capital accounts would be much higher than at present.

Mr. Marshall. Mr. W. P. Marshall observed that wherever the standard gauge of 4 feet 8½ inches[1] had been departed from by the introduction of a

[1] 4 feet 9 inches on the Pennsylvania and the Southern States railroads of North America, amounting to about 6 per cent. of the whole standard gauge mileage.

broad gauge, this had generally been required to be supplemented, Mr. Marsh sooner or later, by a narrow gauge, the average between the two being near the standard gauge. Ireland was an unfortunate instance of this; a broad gauge, 5 feet 3 inches, was fixed upon for the whole country instead of the standard gauge; but this had been found to cause a virtual prohibition of the further extension of railways into the poorer districts of the country, and had in consequence now been supplemented by a narrow gauge (3 feet). The Irish broad gauge, 5 feet 3 inches, had been adopted in Victoria and South Australia, but it had to be supplemented in the latter colony by a narrow gauge, 3 feet 6 inches, as the broad gauge was found prohibitory for the great extensions required into a thinly populated country. In India, for the same reason, the broad gauge, 5 feet 6 inches, had been supplemented by a narrow gauge, 3 feet 3 inches, and the same thing had occurred in South America, where the broad gauge, 5 feet 6 inches, was adopted first, and a narrow gauge, 3 feet 3 inches, had been subsequently chosen for the great extension of the Central Argentine Railway into the interior of the country. In all these cases there seemed strong reasons to believe that, if the standard gauge had been adhered to, it would have answered for all the purposes both of heavy main lines and of light branch and mountain lines; and the subsequent introduction of a narrow gauge would then not have been required, and the present serious evil of break of gauge would have been avoided. In Canada, the broad gauge, 5 feet 6 inches, was adopted originally; but the adjoining railways of the United States being standard gauge, there was so great an obstruction to traffic from the break of gauge, and so heavy a commercial loss in consequence, that the whole of the Canadian broad gauge, amounting to 3,000 miles, was ultimately altered to the standard gauge, after struggling for some time with an intermediate plan of altering the gauge of the wheels of the trains in transit at the frontier. In the Southern States of America, which were then the Slave States, a gauge of 5 feet, as different from the standard gauge, was adopted for the purpose of causing a break of gauge at the frontier, to check the escape of slaves by necessitating change of train; but after the abolition of slavery, the obstruction to traffic and the consequent losses were found so serious that the whole of the railways in the Southern States, 13,000 miles in extent, were simultaneously altered to the standard gauge. A number of narrow-gauge lines of 3 feet gauge still existed in North America, but many such lines had been at different times altered to standard gauge, and about 94 per cent. of all the North

. Marshall. American railway mileage was now standard gauge. In England, for the same reason, 2,000 miles of broad-gauge line, 7 feet, had been similarly altered; and altogether, in different parts of the world, no less than 23,000 miles had been altered to the standard gauge, which now included about 78 per cent. of the whole railway mileage of the world.

Ir. Sawyer. Mr. ERNEST E. SAWYER observed that the subject had been under discussion by the Institution; it was the almost unanimous opinion of the profession, and certainly of all the leading engineers, that the Government of India, by introducing a new gauge, had made a grave mistake. Was this opinion right or wrong? It was satisfactory to find that it was absolutely right. The Author's conclusions, taking the railways in the gross, showed this to be the case. Exception might fairly be taken to this mode of procedure, for he had compared different classes of railways, namely, heavy trunk lines, having a large traffic, with light branch lines having a small traffic. If the 1,400 miles of the Rajputana metre-gauge railway were compared with the 840 miles of the Madras broad-gauge railway, the opposite conclusion, in every respect, would be arrived at. But would any one say this was owing to the gauge? The Madras line was acknowledged to be one of the best managed and maintained lines in India. Its rails were from 65 to 84 lbs. per yard. It had 42 miles of double line, and throughout the bridges and viaducts were constructed for a double line. It was a heavy line in every respect. The Rajputana, laid with 41¼-lb. rails, had only 1 mile of double line out of 1,414 miles, and was constructed strictly for a single line throughout; it was in every respect a light line. As the difference was between the construction of these lines, so it was with regard to the traffic. That on the heavy Madras line was light, and could possibly be increased many times without much extra outlay. That of the light Rajputana was so heavy that it often could not be carried, and the question of doubling the line throughout was under consideration of the Government. It was evident, therefore, that this was not a question of gauge, but of the nature of the construction of the line, which should be regulated by the amount of traffic to be dealt with. The only bad feature about the Rajputana line was its gauge. Had it been built on the broad gauge, as a light railway, there would have been no trouble, as it would only have meant substituting heavy rails and heavier bridges, in accordance with traffic requirements. The gauge was no bad feature on the Madras line. The only alteration required, if it had to be done afresh with the present experience, would be to build it as a light

Mr. Sawye

railway to accommodate a very moderate traffic. It could not be too much insisted on that the term narrow-gauge did not necessarily imply a lighter railway than one of a broader gauge. The West of India Portuguese Railway was a metre-gauge line, having, for very sufficient reasons, 62-lb. rails and 43-ton locomotives. It was a narrow-gauge line, but a heavy railway all the same. Comparing, however, the Rajputana Railway, which was a main line, with the larger main lines, on the whole the broad gauges, relatively to the traffic worked by them, were more economical, and gave a larger return on their outlay. The Rajputana line was being worked to almost the full extent of its traffic, and returned 7·19 per cent. on the capital outlay; the working expenses being 50·99 per cent. The East Indian was not worked to its full capacity, and returned 8·40 per cent. on the outlay, and the working expenses were only 35·27 per cent. That the programme, foreshadowed by the India Office sixteen years ago, had not been carried out was evident by looking at the title of the Paper read at the time. It read: "Particularly for those of the Punjab." Now two metre-gauge railways, the Indus Valley and the Punjab Northern, were both laid down as proposed; but both, after the sad experience of break of gauge during the Afghan war, were taken up and the standard gauge substituted. The cost of this, and of the loss and delay during the war owing to break of gauge, had been estimated as sufficient to pay for many a mile of railway, and he believed had not been included in the cost of metre-gauge line, but had been "wiped out" by the Government of India, and put down to the cost of the war. The next step was to build the Rajputana line on the metre gauge, in spite of the most earnest and strenuous opposition from the merchants of Bombay. It was admitted that the traffic between Ahmedabad and Delhi was often beyond the capacity of the line. The doubling was contemplated, but the cost of doing so was so great that it had been shown to be relatively cheaper to construct an entirely new broad-gauge line, parallel to it, some 50 to 100 miles away. As there was no advantage in introducing the new gauge in the Punjab, so there was none here, and he could not conceive how any person, with the present traffic experience, would still advocate the new gauge on the Rajputana line, if it had to be done again. The conversion of the broad-gauge Carnatic into the metre-gauge South Indian, instead of maintaining the standard gauge, had also proved of very doubtful benefit. That the Indian Government was right in insisting on the construction of light lines there could be no doubt; but that it was wrong in introducing a different gauge

r. Sawyer. would, he supposed, now be admitted. The two self-evident cases of this were the Punjab and the Rajputana Railways. It would be well, however, if an authoritative statement to that effect, on the part of the Government, could be given.

---

19 March, 1889.

SIR GEORGE B. BRUCE, President, in the Chair.

The Discussion on the Paper by Mr. F. J. Waring, on Indian Railways, occupied the whole evening.

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
STAMFORD STREET AND CHARING CROSS.

Discussion.

b.

Page.

22. Waring.
31. Burge.
34. Sir G. Bruce.
36. " H Kimber.
40. " G. Molesworth.
44. Shelford
46. Ross.
48. Wilde.
49. Hodson.
67. Izat
97. Bury.
75. Price Williams.
77. Pilkington.
78. Jebb.
" Whyatt.
79. Capt. Hearn.
" Sist
87. Upcott's – Reply.

Correspondence.

90. Col. Boughey.
92. Brunton.
95. Cardew.
97. Egerton.
99. Godfrey.
102. Lart.
105. H. B. Molesworth.
106. Preston.
108. Robertson.
109. Shadbolt.
113. Spring.
117. Sykes.
120. Thomson.
124. Wolley-Dod.
132. Upcott's – Reply.

THE

RAILWAY-GAUGES OF INDIA.

BY

SIR FREDERICK ROBERT UPCOTT, K.C.V.O., C.S.I.,
M. INST. C.E.

WITH AN ABSTRACT OF THE DISCUSSION UPON THE PAPER.

EDITED BY

J. H. T. TUDSBERY, D.Sc., M. INST. C.E.,
SECRETARY.

By permission of the Council.
Excerpt Minutes of Proceedings of the Institution of Civil Engineers.
Vol. clxiv. Session 1905–1906. Part ii.

LONDON:
Published by the Institution,
GREAT GEORGE STREET, WESTMINSTER, S.W.
[TELEGRAMS, "INSTITUTION, LONDON." TELEPHONE, "WESTMINSTER 51."]
1906.

ADVERTISEMENT.

The Institution as a body is not responsible either for the statements made, or for the opinions expressed, in the following pages.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
DUKE STREET, STAMFORD STREET, S.E., AND GREAT WINDMILL STREET, W.

THE INSTITUTION OF CIVIL ENGINEERS.

SECT. I.—MINUTES OF PROCEEDINGS.

30 January, 1906.

Sir ALEXANDER RICHARDSON BINNIE, President,
in the Chair.

(*Paper No. 3586.*)

"The Railway-Gauges of India."

By Sir FREDERICK ROBERT UPCOTT, K.C.V.O., C.S.I., M. Inst. C.E.

THE subject of the Railway-Gauges of India was discussed at the Institution in 1873,[1] and again, after an interval of 16 years, in 1889.[2] A similar interval has now elapsed, and the present seems to be an appropriate time to review what has been done since the latter date, and to examine the possibilities of gradually attaining uniformity of gauge, and the advantages to be obtained thereby. The questions which naturally arise are: (1) whether the cost and confusion which will necessarily accompany gradual conversion outweigh the advantages of uniformity; and (2) whether the growing needs of traffic may not be met by continuation and extension of different gauges, treating each case on its merits, without attempting to establish any definite scheme.

In examining these questions it is hardly necessary to take into account the countries bordering on India which may in the future connect with the Indian railway-system, because Russia and China have adopted gauges differing from those in India, and Persia has only a few miles of railway at the present time. India is a vast country, and the bulk of its imports and exports are carried by sea. Moreover, its internal trade is very large, and its overland trade with these countries can hardly become of sufficient importance to warrant the adoption of a gauge differing from those now in existence in India.

The policy which was formulated in the early seventies, and reiterated at the close of 1888, of adopting two gauges and restricting

[1] Minutes of Proceedings Inst. C.E., vol. xxxv. p. 214.
[2] *Ibid.*, vol. xcvii. p. 106.

them to certain defined areas, has not been rigidly adhered to, the pressure of trade requirements and of rival interests having resulted in encroachments by each on the other's territory, induced by the necessity of linking groups of railways of similar gauge. Until 1890 the area served by the metre-gauge lines was fairly well defined, being limited to the country north and east of the Ganges River, starting from longitude 80° E., the whole of Burma, Rajputana, and Gujrat, and the country south and west of the standard-gauge line connecting Bombay and Madras; but by that time the metre-gauge lines had gradually increased in efficiency with heavier and larger rolling stock and permanent way, so that they passed out of the category of light lines. On the other hand, the later standard-gauge lines were built at less cost per mile than the earlier ones, and thus it became a still more difficult question to decide which gauge should be adopted in any given case, the difficulty being accentuated by the very reasonable demands of the metre-gauge lines to obtain access on their own gauge to all the large centres of trade near them on the standard-gauge lines, as well as to be linked with adjacent metre-gauge systems, and in some cases to obtain connection with the sea-ports. The result has been that, in giving effect to some of the demands of the metre-gauge lines, the standard-gauge lines have been crossed at many places, and the gauge that was originally intended to feed the standard-gauge lines has become competitive: this, however, may be held to have actually resulted in benefit to the country and to trade, rather than the reverse, as has been often asserted by those who deprecate rivalry in the great arteries of traffic.

The present result is that at the close of 1903 there were in India 14,477 miles of standard or 5-foot 6-inch gauge, 11,421 miles of metre or 3-foot $3\frac{3}{8}$-inch gauge, 796 miles of 2-foot 6-inch gauge, and 262 miles of 2-foot gauge, open to public traffic, making a total of 26,956 miles; while 1,162, 1,273, 575 and 113 miles respectively were under construction and sanctioned. The map (Figs. 1–6, Plate 1) shows that to a large extent the areas originally set apart for the metre-gauge lines have been fairly well preserved, although, as was inevitable, certain connections have been made between the systems served by the metre-gauge lines. Thus the metre-gauge lines north of the Ganges have been joined with the metre-gauge systems of Rajputana on the west and with the Assam metre-gauge system on the east, while the Gujrat metre-gauge system has been joined to that of Rajputana. The Rajputana system has approached the sea-port of Karachi and may press for the short extension to that port, although there is already a double standard-gauge track between Kotri and Karachi. An extension of the metre-gauge line from

Khandwa to Hotgi appears likely to be necessary in the near future, to link up the southern and northern metre-gauge system; while the metre-gauge line along the Godavari valley was undertaken by the Nizam's Government with a view to open out that country as economically as possible, instead of laying down a light standard-gauge line. This line may possibly be extended southward to Karnul, and there is a desirable link between Mysore and Erode still awaiting construction. The metre-gauge lines do not threaten to enter Bombay, and it is likely that the important development of Marmagao as a seaport for Europe may defer for many years any extension towards Bombay. With regard to Calcutta, the metre-gauge lines at present tranship across the Ganges River to standard-gauge lines leading to the Port, and whilst the existing conditions of the traffic do not appear to call for such connection, the want of bridges across the Ganges River at points where the largest transhipments take place is now beginning to be felt. Of the 2-foot 6-inch and 2-foot gauges, now reaching a total length of 1,058 miles, it may be said that the success of the first two lines on these gauges, the Darjiling and the Barsi lines, both constructed by private companies, not only drew the attention of the military authorities to the capabilities of a small gauge for serving hilly tracts at a reasonable cost, to act as pioneer lines for the standard gauge, but has also led to other lines being started as tramways which have eventually developed into railways. These small-gauge lines do not, in general, serve metre-gauge lines, but have been built as continuations of, and feeders to, the standard-gauge lines.

The Tables given in the Appendix, which have been compiled from the Railway Administration Report[1] for 1903, present, so far as statistics can help to solve the problem, a fair basis for comparison of the relative merits of the standard- and metre-gauge systems. It is not claimed that an exact comparison can be drawn between them, because the conditions are not entirely similar; the physical nature of the country varies greatly, and strategic considerations have often compelled the adoption of a more expensive line than the commercial importance of the country justified. Nor is it suggested that the Government could, under the numerous contracts entered into with companies for working State-owned lines, carry out any sudden or drastic change; any approach to uniformity that may be possible and desirable must of necessity be gradual. It may also be noted that the question of actual profit or loss to the Imperial

---

[1] C. W. Hodson, "Administration Report of the Railways in India for the calendar year 1903." Simla, 1904.

Government does not enter into the scope of the present inquiry, because, although the Indian railway-system does now yield a handsome profit to the Government—who are the owners of nearly the whole of it—yet, owing to the plan originally adopted of guaranteeing sterling interest on lines since purchased, to the fluctuations of silver, to the premiums paid on purchase of the older lines, and to the provision, for its own lines, of capital raised partly by borrowing at various rates of interest and partly from the general revenues of the country, it is very difficult to calculate closely what may be called the fixed charges. Suffice it to say that 4 per cent. is generally accepted as approximately correct.

It is hardly necessary in this Institution to demonstrate the advantages of uniformity of gauge, but it may not be out of place to mention the more important benefits to India that would result from uniformity. It would eliminate the troubles and expense of transhipment and the maintenance of the intricate tracks that are unavoidable where the two systems converge at the great centres of trade, the seaports, and the coal-fields. It would afford India a much wider field to draw upon for rolling stock when, as often happens, there is a glut of traffic in one particular area, such as may be occasioned by the natural effects of a normal rainfall producing heavy crops, or by a deficiency in the rainfall causing a famine: either of these causes results in abnormal movements of grain-foods. Military concentration of troops, material, and supplies has the same effect. In India the periods of trade and the movements to or from the sea-board are irregular, and the set of traffic frequently changes; for these reasons it is absolutely necessary to provide a full equipment of rolling stock to meet a maximum traffic for a short period, although the stock may not be fully employed throughout the year. It is evident that the distribution of rolling stock would be immensely facilitated, and the equipment more effectively and economically utilized, if the whole country were served by one gauge. A good deal is done at present by mutual borrowing, when it happens that the movements of commodities on adjacent systems occur in different months; for example, the jute-traffic from the interior to the sea-board takes place at a different time from the movement of grain and seed; and as these commodities are served by distinct railway-systems, the latter are able to use each other's rolling stock, to mutual advantage. There is no private ownership of railway-wagons in India. Some schemes have indeed been proposed, but as they have been based on a guarantee of traffic either from the railways or from the Government, they

have not been favourably received. Still, it is obvious that, under the varying conditions of trade, the greater the area served by one gauge, the greater will be the possibility of mutual accommodation.

Uniformity may be brought about by changing all metre-gauge lines to the standard gauge, by changing all standard-gauge lines to the metre gauge, or by adopting another intermediate gauge, preferably the European gauge of 4 feet 8½ inches. By adopting the first course, a change would be made from the less to the more efficient gauge in respect of carrying-capacity and speed, with considerable expenditure of money. The second course would provide a lower standard of carrying-capacity, with a comparatively smaller outlay. The third course would be more costly and certainly more prolonged than either of the other two. In reviewing these three methods it may be assumed that the ultimate limit of capacity is proportional to the gauge when that limit is reached; but until the volume of traffic has attained its ultimate limit on any gauge there is no loss of power. The theory that the gauge of a railway is the fundamental unit of measurement to which all other dimensions should be proportional, ought to be governed by the foregoing qualifications. Now that the traffic of some of the single metre-gauge lines has outgrown their carrying-capacity, the question has arisen whether it would be better, in the present condition of the system of Indian railways, to substitute a single standard-gauge track or to double the metre-gauge line. There is no doubt a great deal to be said in favour of a uniform gauge of 3 feet 3⅜ inches, but the existence of 14,477 miles of standard-gauge track against 11,421 miles on the metre-gauge actually constructed, must greatly modify the aspect of the problem, although the conversion of the existing rolling stock from standard to metre gauge is a much greater difficulty than the reverse.

For the purpose of comparing the leading features of the two gauges, the eight principal lines on each gauge have been selected, and various particulars relating to them are given in the Appendix. In making comparisons there are certain facts to be remembered: first, that so far all the metre-gauge lines are single tracks, whilst 1,360 miles, or about 9 per cent., of the standard-gauge lines are double tracks; secondly, that the branches to the metre-gauge lines, especially north of the River Ganges, are much more numerous than those to the standard-gauge lines; and thirdly, that the coal-fields are served almost entirely by standard-gauge lines, as is shown by the fact that in 1903, whilst the standard-gauge lines carried 7½ million tons of coal, the metre-gauge lines carried only the insignificant total of 112,000 tons. The year 1903 has been taken, not only because it is the most recent for which

complete statistics are available, but also because some of the metre-gauge lines had then nearly arrived at their maximum capacity on a single track. The statistics have been compiled to exhibit in as fair a manner as possible the comparative value of the gauges. The Author does not claim that the question laid before the profession can be decided by figures; there are so many circumstances which have to be taken into account that it seems almost an insoluble problem. So far, the evil of the two gauges has not been so great as was anticipated, but there is a feeling among many whose knowledge of the subject entitles them to be heard, that the confusion will grow from year to year, unless some more definite policy is adhered to than that which has been followed during the last 30 years. It is considered that there is a distinct danger lest the whole continent may be covered with a network of lines, of three different gauges; and that the metre-gauge and the 2-foot 6-inch gauge, originally introduced on the plea of cheapness and lightness, will, in course of time, be so strengthened that they will be able to carry a traffic that would almost support the standard gauge.

While admitting the obvious advantages of uniformity of gauge, there is an equal danger of purchasing it at too dear a price. On
16.17 examination of Tables I and II, the great difference in capital cost of the two gauges—£11,775 per mile for the standard gauge, and £4,700 per mile for the metre gauge—is at once noticed. It must be remembered, also, that when the construction of railways was begun, in 1845, on the standard gauge, the cost was much higher than it was 30 years later. Very high rates had to be paid to contractors in order to induce them to undertake the risks attending novel works in a foreign country, where there was nothing to establish a precedent as regards cost of construction. There is also to be taken into account the fact that 9 per cent. of the standard-gauge lines is double track; but, allowing for this, although the Government Administration Report on all the railways in India gives the cost of the standard- and metre-gauge lines as £10,666 and £5,133 per mile respectively, the difference in capital cost affords ample justification for the early policy of adopting the smaller gauge: had it not been allowed, about 5,000 miles of the present railway-lines would probably not now be in existence. At no time has there been any serious attempt to lay down an inexpensive standard-gauge line equipped with suitable light rails, rolling stock and station-accommodation; and, indeed, the existence of a sanctioned narrow-gauge has prevented this from being done. Possibly, however, it may be argued that, had only the standard gauge been allowed, this light system might have come into existence, although the severe conditions of equipment which obtain in India lead rather to the opposite conclusion.

It is interesting to note that the return on capital and the cost of working of the two gauges are nearly alike. Incidentally it is significant that the smaller gauge carried, in the year 1903, a larger average number of passengers per train than the standard gauge; the difference in the average tonnage per train is accounted for almost entirely by the larger number of branches on the metre-gauge lines, and by the coal-fields being served almost entirely by the standard-gauge lines. The difference in carrying-capacity of the two gauges may be taken from the statistics in a variety of ways, with considerable difference between the results. Table IV (Appendix) p. 19 shows the average speeds to be 23, 12 and 15 miles per hour on the standard-gauge, as compared with 18, 10 and 13 miles per hour on the metre-gauge lines, for passenger-, mixed, and goods-trains respectively. Neglecting these small differences, and making the reasonable assumption that an engine of either gauge will pull an equal number of vehicles or wagons, then, since a four-wheel standard-gauge passenger-vehicle will hold sixty passengers, and a four-wheel metre-gauge coach only forty passengers, and since a four-wheel standard-gauge wagon will carry 16 tons and a four-wheel metre-gauge wagon only 10 tons, the ratio of the passenger-vehicle capacity of the standard-gauge to that of the metre-gauge is found to be 1·5 to 1, and the ratio of the goods-wagon capacities 1·6 to 1. Also, from the gross weight of a train, neglecting speed, the ratio of the train-capacities is found to be 1·4 to 1 for passenger-trains and 2 to 1 for goods-trains. In the following Table are shown, in addition to the foregoing, the ratios of the carrying-capacities of the two gauges, obtained by some of the other methods of comparison, compiled from the Railway Administration Report, but confined to the sixteen railway-lines which have been taken as examples:—

		Ratio: Standard Gauge	to	Metre Gauge.
Vehicle capacity only	Passenger	1·5	to	1
	Goods	1·6	„	1
The same, taking speed into account	Passenger	1·9	„	1
	Goods	1·9	„	1
Gross weight of trains	Passenger	1·4	„	1
	Goods	2·0	„	1
The same, taking speed into account	Passenger	1·9	„	1
	Goods	2·4	„	1
Vehicle mileage, loaded and empty	Coaching	1·9	„	1
	Goods	2·8	„	1
The same, taking speed into account	Coaching	2·4	„	1
	Goods	3·3	„	1
On actual number of passengers carried 1 mile		2·0	„	1
„ „ „ „ tons „ 1 „		4·7	„	1

It will be observed that, whilst the benefit to be derived from conversion is greater for goods-trains than for passenger-trains, it

may fairly be assumed that the general capacity of the standard gauge is double that of the metre gauge, under the conditions of speed, power of engines, and design of coaches and wagons at present obtaining in India. An independent check on the foregoing is afforded by the ton-mileage per engine. The engine of the principal standard-gauge line (the East Indian) accomplishes on an average 7,838 thousand, and that of the principal metre-gauge line (the Bengal and North Western) 3,962 thousand ton-miles. It may also be mentioned incidentally that the ratio of the total gross earnings derived from the goods-traffic of both gauges, to that from the passenger-traffic, is 1·9 to 1, and of the total gross earnings derived from the whole traffic of the standard gauge to that from the metre gauge, 3·05 to 1.

In estimating the cost of converting from the metre gauge to the standard gauge, it must be remembered that the Indian Government have laid down certain rules governing the axle-loads on girder-bridges and on rails; but the precaution is now to be adopted of renewing with standard-gauge girders girders on metre-gauge lines which may require doubling in the near future. This entails a very small addition to the cost, as the tendency is towards heavier engines on both gauges.

The diagrams for fixed and running dimensions are shown in Figs. 7 and 8, Plate 2. It will be noticed that tunnels have been built for the wider gauge only, and that the platform-faces are nearly the same distance from the inner rail in both cases. With regard to conversion of the existing rolling stock, little difficulty is to be apprehended, provided it be taken in hand some time before the conversion of the gauge is actually begun. The actual cost of converting a metre-gauge to a standard-gauge line is not a matter of estimate, since particulars of the cost of conversions already effected are available. The figures for the Salt Branch of 50 miles of the North Western railway were :—

	Rupees.	£	per mile £
Land.	32,000	2,150	43
Formation	70,000	4,650	93
Bridges	75,000	5,000	100
Ballast	1,90,000	12,650	253
Permanent way (75-lb. flat-footed rails and 9-foot wood sleepers for 41-lb. flat-footed rails and 6-foot timber sleepers)	10,35,000	69,000	1,380
Stations	1,40,000	9,350	187
Plant	8,000	550	11
Rolling stock	5,00,000	33,350	667
General charges	1,00,000	6,650	133
Total	Rs.21,50,000	£143,350	2,867

Equal to Rs.43,000, or £2,867, per mile.

The cost of converting the Nagpur-Chhattisgarh line, 145½ miles in length, taken over by the Bengal-Nagpur railway, was:—

	Rupees.	£
Land	34,000	2,250
Formation	2,48,000	16,550
Bridges	8,33,000	55,550
Ballast	4,12,000	27,450
Permanent way	29,36,000	195,750
Stations	2,74,000	18,250
Plant	65,000	4,350
Rolling stock	6,98,000	46,550
General charges	1,38,000	9,200
Total	Rs.56,38,000	£375,900

Equal to Rs.38,750, or £2,583, per mile.

A metre-gauge line, 27·88 miles in length, between Kotkapura and Firozpur, was converted to standard gauge at a cost of 22,080 rupees, or £1,472, per mile; and 24·23 miles of metre-gauge line from Gudur to Nellore were converted at a cost of 61,879 rupees, or £4,125, per mile. In the latter case the cost was exceptionally high, on account of the bridge-renewals and heavy permanent way. No rolling stock is included in either case.

No actual costs of doubling a metre-gauge line can be given, as a case has not yet arisen, but the following is an estimate of the probable cost per mile:—

	Rupees per Mile.	£ per Mile.
Land	7,000	470
Formation	2,000	130
Bridges	8,000	530
Ballast	4,000	270
Permanent way	20,000	1,330
Rolling stock	8,000	530
General charges	1,000	70
Total	Rs.50,000	£3,330

In this estimate, a moderate increase of rolling stock is provided for. It is difficult to say how much will be required, because, owing to the higher speed obtained with a double track, there may not be at first any necessity for material increase of the rolling stock.

Assuming a level road, trains of the same speed and length, and an equal number of trains in each direction, passing alternately under ordinary "line clears"—which is the Indian system of working—the interval which must occur between the passage of two successive trains in the same direction on a single line is equal to twice the longest time taken between two adjacent crossing-stations, plus the longest time occupied at any one crossing-station in shunting, watering, etc.; and for a double track the interval is equal to the longest time taken between two adjacent stations, plus the longest

occupied at a stopping-station, which will be about half of that taken on a single track; thus, theoretically, the increase in the number of trains which can be run in a given time, due to doubling, would appear to be about 100 per cent. In practice, however, the foregoing conditions do not obtain. With speeds varying between 15 and 30 miles per hour and crossing-stations not more than 5 miles apart, the limit of capacity on a single track is about fifteen trains in 24 hours, and on a double track sixty or eighty trains in the same time, or about five times the capacity of the single track. At times of great pressure, it has been possible largely to increase the capacity of the single track by running trains in one direction for two or three days together. In England, by working light fast trains with block-stations close together, as many as two hundred trains can be run daily on a double track; but nothing like that number has hitherto been attempted in India, owing to the speeds being so much lower, and to the cumbrous system of written "line clears" being still in vogue on most of the lines.

Transhipment of passengers and goods has to be effected across narrow platforms at suitable levels; or, where a river separates the different gauges, by means of boats and barges, or carriage- and wagon-ferries. In the first case, when both gauges are worked by the same administration, the delay and difficulties are reduced to a minimum; the most notable instance is the junction between the Rajputana-Malwa metre-gauge line and the Bombay-Baroda standard-gauge line, near Ahmedabad. There the average cost of transhipment over 5 years is found to be 5½*d*. per ton of all classes of goods, being equivalent to an extra haulage of 20 miles. It is convenient if the transhipment is carried out in even multiples, such as three metre-gauge 10-ton wagons to one standard-gauge 30-ton wagon. Where, however, a river divides the two lines and is unprovided with a wagon-ferry, the delay, loss, and cost reach a maximum, as every package has to be handled twice. In this case the cost varies between 9*d*. and 1*s*. 3*d*. per ton for goods. Where wagon-ferries are established, transhipment takes place with greater dispatch and less loss, but, owing to the heavier cost of the plant, the charges are not sensibly reduced. A bridge affords, of course, the most efficient method of transfer where a river intervenes, when the necessity for it can be established by reason of the amount of traffic handled. The delay, cost, and inconvenience to passengers are also very great in the three cases mentioned, but the unbridged river is such a troublesome and expensive impediment to all traffic, that there is little doubt that most of the rivers where breaks of gauge occur will be bridged long before there is uniformity of gauge in India.

The cost of converting the Nagpur-Chhattisgarh line, 145½ miles in length, taken over by the Bengal-Nagpur railway, was:—

	Rupees.	£
Land	34,000	2,250
Formation	2,48,000	16,550
Bridges	8,33,000	55,550
Ballast	4,12,000	27,450
Permanent way	29,36,000	195,750
Stations	2,74,000	18,250
Plant	65,000	4,350
Rolling stock	6,98,000	46,550
General charges	1,38,000	9,200
Total	Rs.56,38,000	£375,900

Equal to Rs.38,750, or £2,583, per mile.

A metre-gauge line, 27·88 miles in length, between Kotkapura and Firozpur, was converted to standard gauge at a cost of 22,080 rupees, or £1,472, per mile; and 24·23 miles of metre-gauge line from Gudur to Nellore were converted at a cost of 61,879 rupees, or £4,125, per mile. In the latter case the cost was exceptionally high, on account of the bridge-renewals and heavy permanent way. No rolling stock is included in either case.

No actual costs of doubling a metre-gauge line can be given, as a case has not yet arisen, but the following is an estimate of the probable cost per mile:—

	Rupees per Mile.	£ per Mile.
Land	7,000	470
Formation	2,000	130
Bridges	8,000	530
Ballast	4,000	270
Permanent way	20,000	1,330
Rolling stock	8,000	530
General charges	1,000	70
Total	Rs.50,000	£3,330

In this estimate, a moderate increase of rolling stock is provided for. It is difficult to say how much will be required, because, owing to the higher speed obtained with a double track, there may not be at first any necessity for material increase of the rolling stock.

Assuming a level road, trains of the same speed and length, and an equal number of trains in each direction, passing alternately under ordinary "line clears"—which is the Indian system of working—the interval which must occur between the passage of two successive trains in the same direction on a single line is equal to twice the longest time taken between two adjacent crossing-stations, plus the longest time occupied at any one crossing-station in shunting, watering, etc.; and for a double track the interval is equal to the longest time taken between two adjacent stations, plus the longest time

effected over an entire system at the same time, it will be necessary to convert the main line section by section, beginning at the junction with the standard-gauge line. This would naturally throw the branch junctions into transhipment-stations until they could be taken in hand; but even assuming that the conversion can be carried out under the most favourable conditions of long preparation beforehand, the ultimate advantages of conversion to the standard-gauge single track, and of doubling the metre-gauge track, have still to be compared. The cost has been shown to be about one-quarter more in the latter case. On the one hand, conversion to the standard gauge will give double the carrying-capacity—at the expense, however, of great dislocation of traffic for the time—freedom of access to all ports and collieries without restriction, complete supplies of rolling stock to meet all conditions of abnormal traffic, higher speeds, and greater comfort for the travelling public in more roomy carriages: but all this is coupled with the prospect of having in a short time to double the standard-gauge line. On the other hand, the doubling of the metre-gauge lines will give at once four or five times the capacity of the single line; it can be carried out by degrees, as funds are available, without any dislocation of traffic; it will provide for, say, another 30 years' increase of traffic; but the seaports will be open to that gauge only under great pressure, and at very great cost, while the coal-fields will probably remain closed to it. Large towns have not hitherto been found to present difficulties that cannot be overcome, and as the land is acquired by Government free of cost, the companies managing metre-gauge lines have not been slow to press their claims to equal treatment with the standard-gauge lines, in being allowed access thereto.

It seems probable that the metre-gauge lines in the South of India will be the first to be considered, with regard to doubling or conversion; then possibly those in Rajputana. The metre-gauge lines north of the Ganges River and Assam are fairly isolated, and may be doubled on that gauge without fear of prejudicing the question; whilst Burma is at present wholly isolated, and a considerable time must elapse before its system connects with Assam, or Siam, or China. In the meantime the construction of new lines must go on. Taking periods of 10 years since 1853, when, in Lord Dalhousie's viceroyalty, railways were begun, the progress has been 2,507 miles up to 1863, 5,697 miles up to 1873, 10,458 miles up to 1883, 18,504 miles up to 1893, and 26,956 miles up to 1903, showing average yearly additions of 250, 319, 476, 804 and 845 miles in each decade; whilst during the 5 years of Lord Curzon's viceroyalty the average has risen to nearly 1,000 miles.

Assuming future advance at the same rate, which will, however, be mostly branches of existing systems now that the main arteries of traffic are complete, it is unlikely that funds will be available for conversion solely for the sake of bringing about uniformity, except in circumstances which do not at present exist. So far, India is not much hampered by the different gauges; but it appears to be a wise precaution to look ahead and endeavour beforehand to have a clear idea of what will be to the best advantage of the future development of traffic; and it is with a view to obtain the criticism of the members of the Institution that this subject has been put forward for discussion.

The Paper is accompanied by four lithographed drawings and a map, from which Plate 2 has been prepared; also by the following Appendix.

[APPENDIX.

APPENDIX.

Table I.—Standard-Gauge Railways, 1903.

Railway.	Mileage.	Cost per Mile.		Return on Capital.	Per Cent. of Working.	Average Charge per Passenger-Mile.		Average Cost of Carriage per Passenger-Mile.		Average Number of Passengers per Train.	Average Charge per Ton-Mile.		Average cost of Carriage per Ton-Mile.		Average Weight per Train.	Average Percentage Freight to Gross Weight of Train.	Gross Earnings per Mile per Annum.	
	Miles.	Lacs of Rs.	£	Per Cent.	Per Cent.	Pie.	Pence.	Pie.	Pence.	No.	Pie.	Pence.	Pie.	Pence.	Tons.	Per Cent.	Rupees	£
East Indian .	2,231	2·24	15,000	9·4	34	2·67	0·22	0·79	0·06	210	4·17	0·35	1·46	0·12	240	43	33,000	2,200
Eastern Bengal	278	2·77	18,000	6·4	54	2·72	0·23	1·34	0·11	188	4·73	0·39	3·72	0·31	150	34	36,780	2,452
Oudh and Rohilkhand . .	1,106	1·17	7,800	5·3	49	2·65	0·22	1·23	0·10	155	5·01	0·42	2·50	0·21	137	33	12,000	800
Great Indian Peninsula .	2,745	1·94	13,000	7·7	51	2·52	0·21	1·57	0·13	131	6·50	0·54	3·07	0·26	145	25	20,670	1,378
North Western	3,744	1·44	9,600	4·8	49	2·43	0·20	1·06	0·09	176	5·08	0·42	2·60	0·22	161	40	18,120	1,208
Bengal-Nagpur	1,667	1·33	8,900	3·0	54	2·47	0·21	1·13	0·09	212	4·73	0·39	2·76	0·23	138	36	8,730	582
Madras . . .	1,400	1·37	9,100	3·6	58	2·43	0·20	1·30	0·11	233	6·70	0·56	4·24	0·35	107	21	12,400	827
Bombay Baroda and Central India . . .	825	1·91	13,000	5·9	50	2·55	0·21	1·55	0·13	221	7·95	0·66	3·55	0·29	262	43	23,850	1,590
Total . . .	13,996	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Average . . .	..	1·77	11,800	5·7	50	2·55	0·21	1·25	0·10	191	5·61	0·46	2·99	0·25	167	34	20,693	1,380

TABLE II.—METRE-GAUGE RAILWAYS, 1903.

Railway.	Mileage.	Cost per Mile.		Return on Capital.	Per Cent. of Working.	Average Charge per Passenger-Mile.		Average Cost of Carriage per Passenger-Mile.		Average Number of Passengers per Train.	Average Charge per Ton-Mile.		Average Cost of Carriage per Ton-Mile.		Average Weight per Train.	Average Percentage Freight to Gross Weight of Train.	Gross Earnings per Mile per Annum.	
	Miles.	Lacs. of Rs.	£	Per Cent.	Per Cent.	Pie.	Pence.	Pie.	Pence.	No.	Pie.	Pence.	Pie.	Pence.	Tons.	Per Cent.	Rupees	£
Bengal North Western . .	1,418	0·79	5,300	6·3	43	2·05	0·17	0·75	0·06	208	5·82	0·49	2·23	0·19	101	42	8,383	559
South Indian .	1,249	0·69	4,600	8·5	39	2·14	0·18	0·69	0·06	302	7·22	0·60	3·36	0·28	79	40	10,318	688
Burma . . .	1,323	0·94	6,250	4·0	61	3·16	0·26	1·50	0·12	209	7·08	0·59	5·01	0·42	73	35	10,260	684
Eastern Bengal	732	0·94	6,250	5·6	50	2·65	0·22	1·51	0·12	194	7·51	0·63	4·28	0·36	83	36	10,330	689
Southern Marhatta . . .	1,646	0·85	5,650	2·5	62	2·26	0·19	1·34	0·11	185	6·86	0·57	4·42	0·37	76	38	5,806	387
Rajputana-Malwa . .	1,871	0·76	5,000	7·6	50	2·16	0·18	1·15	0·10	240	6·66	0·55	3·31	0·28	128	47	11,885	792
Jodhpur-Bikaner	824	0·25	1,700	6·6	50	2·17	0·18	1·14	0·10	187	7·82	0·61	3·43	0·29	81	38	3,329	222
Rohilkhand-Kumaun . .	280	0·46	3,000	7·0	48	2·59	0·22	1·14	0·10	166	6·69	0·56	3·60	0·30	87	40	6,485	432
Total . . .	9,343	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Average . .	..	0·71	4,750	6·0	50	2·40	0·20	1·15	0·096	211	6·89	0·57	3·70	0·31	88	39	8,349	557

TABLE III.—THOUSAND PASSENGER-MILES AND THOUSAND TON-MILES DURING 1903.

Railway.	Thousand Passenger-Miles.	Thousand Ton-Miles.	Remarks.
Standard Gauge.			
East Indian	1,417,665	2,227,443	Nearly 9 per cent. of these lines are double track.
Eastern Bengal	216,199	153,624	
Oudh and Rohilkhand	394,233	257,503	
Great Indian Peninsula	874,084	1,223,607	
North Western	1,183,232	1,315,489	
Bengal-Nagpur	415,176	362,087	
Madras	476,766	283,145	
Bombay, Baroda and Central India	405,059	294,571	
Average per mile of track	385	437	
Metre Gauge.			
Bengal North Western	458,027	213,814	All these lines are single track.
South Indian	587,977	149,265	
Burma	386,051	181,569	
Eastern Bengal	213,179	111,135	
Southern Marhatta	263,501	162,724	
Rajputana-Malwa	605,676	414,581	
Jodhpur-Bikaner	82,581	42,221	
Rohilkhand-Kumaun	50,740	28,162	
Average per mile of track	283	140	

TABLE IV.—AVERAGE SPEEDS AND AVERAGE GROSS WEIGHT OF TRAINS DURING 1903.

Railway.	Average Through Speed per Hour.			Average Gross Weight of Trains.		
	Passenger.	Goods.	Mixed.	Passenger.*	Goods.	Mixed.*
	Miles.	Miles.	Miles.	Tons.	Tons.	Tons.
East Indian	20	14	17	197	487	240
Eastern Bengal	19	15	14	173	422	217
Oudh and Rohilkhand . . .	29	13	18	185	333	225
Great Indian Peninsula . .	27	13	13	157	351	..
North Western	21	12	15	205	330	250
Bengal-Nagpur	26	11	17	197	332	340
Madras	26	12	10	151	348	276
Bombay, Baroda and Central India	21	10	14	162	562	246
Average	23	12	15	178	396	256
Bengal North Western . . .	17	10	12	151	182	163
South Indian	18	10	12	85	152	167
Burma	19	11	13	131	166	174
Eastern Bengal	19	11	13	112	225	143
Southern Marhatta	16	7	12	95	273	212
Rajputana-Malwa	18	10	14	105	251	138
Jodhpur-Bikaner	19	11	13	93	176	117
Rohilkhand-Kumaun . . .	17	10	14	not	furni	shed
Average	18	10	13	110	204	159

* For the purposes of these Tables passengers are taken as weighing, with luggage :—

1st class . . . . 0·10 ton.
2nd ,, ... 0·08 ,,
3rd ,, ... 0·06 ,,

c 2

TABLE V.—THOUSAND PASSENGER-VEHICLE MILES AND THOUSAND GOODS-VEHICLE MILES DURING 1903.

Railway.	Thousand Passenger-Vehicle Miles.	Thousand Goods-Vehicle Miles.	Railway.	Thousand Passenger-Vehicle Miles.	Thousand Goods-Vehicle Miles.
Standard Gauge.			*Metre Gauge.*		
East Indian . .	119,480	304,185	Bengal North Western . .	50,569	58,386
Eastern Bengal .	17,447	30,628	South Indian .	40,230	39,527
Oudh and Rohilkhand . . .	36,610	50,033	Burma . . .	38,800	56,643
Great Indian Peninsula .	103,370	215,820	Eastern Bengal	21,171	35,328
North Western .	106,008	219,640	Southern Marhatta . . .	30,218	47,088
Bengal-Nagpur .	37,893	58,368	Rajputana-Malwa . . .	60,882	97,554
Madras . . .	37,396	59,727	Jodhpur-Bikaner	9,488	12,490
Bombay, Baroda and Central India . . .	29,342	44,738	Rohilkhand-Kumaun . . .	5,912	7,486
Average . . .	60,943	122,892	Average . .	32,159	44,313

METHOD OF CALCULATING COST PER PASSENGER-MILE AND PER TON-MILE.

The average cost per passenger-mile and per ton-mile is calculated by dividing the working-expenses in the ratio of the gross ton-mileage of freight and of dead load, assuming the weights of the passengers, with luggage, to be :—First-class, 0·1 ton ; second-class, 0·08 ton ; intermediate- and third-class, 0·06 ton. For example, taking the East Indian Railway passengers for 1903 in thousands :—

First-class	10,550 × 0·1 ton =	1,055
Second-class	28,277 × 0·08 „ =	2,262
Intermediate-class	102,655 × 0·06 „ =	6,159
Third-class	1,276,183 × 0·06 „ =	76,571
		86,047
Add other coaching traffic, parcels, etc., in ton-miles		21,880
		107,927
Total dead weight in ton-miles		1,836,741
Total coaching		1,944,668
Goods total freight in thousand tons		2,227,442
Goods total dead weight in thousand tons . . .		2,890,426
Total goods		5,117,868
Total ton-miles		7,062,536,000
Total working-expenses (in rupees) . .		233,63,000
Total gross receipts (in rupees) . . .		713,80,000

Working-expenses in ratio of gross receipts :—

749	22,929
1,587	48,451
2,336	71,380
6,433	19,450
16,930	51,180
23,363	70,630

$$\frac{22,929}{48,451} = \frac{1}{3\cdot 1}$$

$$\frac{19,450}{51,180} = \frac{1}{3\cdot 63} \text{ ratio of ton-miles.}$$

Then the total working-expenses in thousands of rupees, namely, 23,363, divided in the ratio of the ton-miles, namely, 1,945 and 5,118, will give 6,433 and 16,930. If, however, the division be made on the gross receipts from coaching and goods, namely, 22,929 and 48,451 respectively, the ratio is—

	Coaching.	Goods.
	1	3·1
as against	1	3·63 in the former case.

The foregoing passenger-weights give an average of 0·061 ton per passenger, which agrees fairly closely with the figure arrived at by Mr. Jeans in his work on Railway Problems, namely, that for the purposes of ascertaining the proportion of working-expenses due to passengers, as distinguished from goods, fifteen passengers may be taken to weigh 1 ton.

This method shows incidentally, as far as it is considered reliable, the ratio of paying load to dead load in carrying passengers and goods.

Discussion.

he President. The PRESIDENT, in moving a vote of thanks to the Author, remarked that the Paper raised again a question on which valuable discussions had taken place at the Institution in 1873 and 1889; though many of the matters upon which differences of opinion existed then had in the meantime been settled on the basis of actual facts.

Mr. Waring. Mr. F. J. WARING remarked that the Author had given the Institution an opportunity of discussing a subject whose importance could hardly be exaggerated. Before dealing with the Paper itself, he wished to refer to the Paper by Mr. Thornton, read at the Institution in 1873, in which the introduction of the metre gauge into India was defended. It was interesting to find that the evil of break of gauge and the need for concentration of rolling stock, both of which were now fully admitted, were made light of at that time. Mr. Thornton and his supporters in the discussion ridiculed the idea that a break of gauge was equivalent to 20 miles of carriage, but now that also was fully admitted. Finally, the eminent engineers who opposed the introduction of the metre gauge into India were twitted with the remark that, as they had never lived in India, they were hardly competent to form an opinion. It was therefore doubly interesting to find the Author, who held the very important position of Chairman of the Railway Board, to which was entrusted the general control and administration of railways in India, presenting the Paper to the Institution, ostensibly for criticism, but really—judging from the fact that he did not advocate any particular course—for advice. In admitting that the cost of break of gauge was equivalent to 20 miles of carriage, the Author made no reference whatever to the delay which frequently took place at the station where the break of gauge occurred. In 1895 Mr. Waring was deputed by the Government of Ceylon to visit India to report upon the railways in that country; and perhaps he might be permitted to make the following quotation from his report[1]:—

"It has often been said that, with proper management, a block or serious delay of traffic at a transfer station should never occur. To this I have only to reply that at Sabarmati, the junction between the Rajputana-Malwa (metre gauge) and the Bombay-Baroda and Central India (standard gauge) Railways, which, it is to

[1] F. J. Waring, "Indian Railways; Report upon a Recent Visit to India." p. 3. Colombo, 1895.

be noted, are both under the same management, such blocks of traffic are, I understand, by no means unknown. The first result of such a block is that the sidings at the transfer station are choked with laden vehicles, the contents of which cannot be transhipped with sufficient speed; all available sidings at the neighbouring stations then become similarly choked with vehicles, the goods stations throughout the line become choked with traffic, which cannot be despatched owing to the insufficient supply of wagons, and thus the mischief extends in both directions, causing complete dislocation of all traffic arrangements, until by the most strenuous efforts the block of wagons at the transfer station is removed. If this state of affairs can occur when the two railways are under the same management, it is evident that it would be still more likely to happen when the lines were under different ownership. I was informed that this block was not uncommonly caused by the broad gauge line not being able to supply sufficient wagons to take away the traffic brought by the metre gauge line, but this is of course because, just at the moment when the rush of traffic takes place on the metre gauge line, there is a similar rush of local traffic on the standard gauge line, which is only a single one, and on which, even in ordinary conditions, the traffic is much the heavier, and that line has thus to provide not only for an extraordinary rush of its ordinarily heavy local traffic, but for a similar rush of traffic brought on to it by the metre gauge line." Mr. Waring

From the Administration Report on Indian Railways for 1904 he found that the total mileage open was 27,565 miles of line (an increase of 609 miles in the year), consisting of 14,733 miles of 5-foot 6-inch gauge, 11,562 miles of metre gauge, 942 miles of 2-foot 6-inch gauge, and 328 miles of 2-foot gauge. There were also under construction or sanctioned 1,162 miles of 5-foot 6-inch gauge, 1,198 miles of metre gauge and 691½ miles of 2-foot 6-inch and 2-foot gauge. To the reasons which the Author gave for the higher cost of the broad-gauge line the following ought, in fairness, to be added. From the Administration Report for 1902 it appeared that, of the eighty-five bridges in India exceeding 1,000 feet in length, no less than seventy were for the 5-foot 6-inch gauge, and their cost and length were about seven times that of the fifteen bridges on the metre-gauge lines. Of fifty-nine tunnels exceeding 500 feet in length and costing more than a lac and a half of rupees each, no less than forty-five occurred on the 5-foot 6-inch gauge; while their cost (excluding that of the Monghyr tunnel, which was stated not to be known), was nearly five times, and their length more than six times, that of the remaining fourteen tunnels occurring on lines of the other gauge. The details were given in the Table on p. 24. The cost of those large bridges and tunnels worked out at Rs.10,792 per mile of 5-foot 6-inch gauge open, as compared with Rs.2,149 per mile of metre gauge open. Therefore Rs.8,643 per mile of the higher cost of the 5-foot 6-inch gauge was at once accounted for by the existence of the heavier works; but that amount by no means represented the real cost involved, because, as every

Mr. Waring.

NUMBER AND TOTAL LENGTH OF BRIDGES MORE THAN 1,000 FEET, AND OF TUNNELS MORE THAN 500 FEET, IN LENGTH, OR COSTING MORE THAN 1,50,000 RUPEES, EXISTING IN 1902; WITH THEIR TOTAL COST AND COST PER MILE OF LINE OPEN IN 1904.

Description.	Gauge.	Number.	Length.	Cost.	Cost per Mile of Railway Open in 1904.
				Rupees.	Rupees.
Bridges	5 feet 6 inches	70	231,922 feet	1,413,54,551	10,792
Tunnels		45	19,563 yards	176,51,665[1]	
Bridges	Metre	15	33,250 feet	211,36,379	2,149
Tunnels		14	3,016 yards	37,11,402	

TOTAL NUMBER, AND NUMBER PER MILE, OF ENGINES AND ROLLING STOCK ON INDIAN RAILWAYS OF VARIOUS GAUGES; ALSO TOTAL VALUE AND VALUE PER MILE.

Gauge of Railway.	Length in Miles.	Total Number of Engines.	Number of Engines per Mile.	Total Number of Coaching Stock.	Number of Coaching Stock per Mile.	Total Number of Goods Stock.	Number of Goods Stock per Mile.	Total Value of Stock.		Value of Stock per Mile.	
								Rupees.	£	Rupees.	£
5 feet 6 inches	14,733	3,596	0·24	11,476	0·78	68,100	4·62	3,836,65,000	25,577,666	26,040	1,736
Metre . .	11,562	1,792	0·15	7,686	0·66	37,856	3·27	1,327,33,000	8,848,867	11,480	765
2 feet 6 inches	942	113	0·12	473	0·5	1,632	1·73	62,45,000	416,333	6,630	442
2 „ . .	328	58	0·18	257	0·78	721	2·2	20,89,000	139,267	6,370	425

[1] Exclusive of cost of Monghyr Tunnel 300 yards long, which is not known.

engineer was aware, the occurrence of a high ridge rising out of a level plain and necessitating a tunnel was very exceptional. Tunnels were usually situated in hilly, broken country, where for miles on each side the earthworks were heavy, and long culverts, retaining-walls, and high bridge-abutments were necessary. Also, most of the bridges in India crossed rivers which overflowed their banks, and in approaching them long embankments—sometimes several miles in length, and having numerous and large flood-openings—were required. These conditions might perhaps add 50 per cent. to the Rs. 8,643 per mile, which was the cost imposed on the 5-foot 6-inch gauge lines by the occurrence of bridges and tunnels. But there were several other points. The three great ports, Calcutta, Bombay, and Karachi, were served solely by broad-gauge lines as were also the collieries; and, omitting the large towns of India which were served by railways of both gauges, it was found there were many more large towns served solely by 5-foot 6-inch than by metre-gauge lines. It was therefore only fair to assume that the cost of stations, warehouses and sidings must be much higher for the 5-foot 6-inch gauge than for the metre gauge. Further, from the Administration Report for 1904, he found that the number of engines and vehicles per mile, as well as their cost—or, as it was called in the Report, their value—was much higher for the lines of 5-foot 6-inch gauge than for the metre-gauge lines, the exact figures being Rs.26,040 and Rs.11,475 per mile respectively. The weight of the rails on the 5-foot 6-inch gauge averaged 50 per cent. more than on the metre gauge. These considerations, added to those mentioned by the Author, would go far to account for the higher cost of the lines of 5-foot 6-inch gauge. The Author, while admitting the evils of break of gauge, implied that the Government were helpless in the matter, and that if the narrow gauge had not been introduced, about 5,000 miles of railway would probably not have been made. Mr. Waring could not agree with that view, because he considered that the introduction of light standard-gauge lines—the construction of which had been recommended by eminent engineers who took part in the discussion in 1873, and which he also had advocated in replying to the discussion on his own Paper[1] in 1889—would have met the case fully. The Author stated that railways of that class had not been tried in India; but it could not be admitted that the severe conditions of equipment obtaining in that country would have prevented such lines from being successful, because the conditions were made by the Government of India themselves, and Mr. Waring.

[1] Minutes of Proceedings Inst. C.E., vol. xcvii. p. 189.

Waring therefore were not unalterable, but could have been modified by the Government had they thought fit. In respect of those conditions, however, it seemed to him that the metre gauge, being the introduction of the Government, had, not unnaturally, been favoured—certainly as regarded the dimensions of the vehicles; for, while the minimum radius of curves laid down for each gauge was the same multiple of the gauge, in vehicles the greatest width allowed to the standard gauge was less than twice the gauge, whereas the greatest width of a vehicle on the metre gauge was more than two-and-a-half times the gauge. As the following Table also showed, the greatest height of an unladen vehicle on the 5-foot

LIMIT OF CURVATURE OF THE LINE, AND CERTAIN STANDARD DIMENSIONS OF THE VEHICLES IN USE ON THE 5-FOOT 6-INCH AND METRE-GAUGE INDIAN RAILWAYS.

Description.	5-Foot 6-Inch Gauge.			Metre Gauge.		
	Dimensions.		Dimensions in Terms of Gauge (Gauge = 1).	Dimensions.		Dimensions in Terms of Gauge (Gauge = 1).
	Feet.	Ins.		Feet.	Ins.	
Sharpest curve in ordinary country . . . Radius	1,910	0	347·3	1,146	0	349·3
Sharpest curve in difficult country . . . Radius	955	0	173·6	573	0	174·6
Vehicles.						
Maximum width	10	6	1·909	8	6	2·591
„ height for unloaded vehicles at centre . . .	13	6	2·454	11	0	3·353
Longest rigid wheel-base for passenger-vehicles . . .	16	0	2·909	12	0	3·657
Longest rigid wheel-base for goods-vehicles	12	0	2·181	10	0	3·048
Extreme overhang of vehicles on *each* side beyond gauge is thus	2	6	0·4545	2	$7\frac{5}{16}$	0·7953

6-inch gauge was less than two-and-a-half times the gauge, while on the metre gauge it was more than three-and-a-third times the gauge. The longest rigid wheel-base for passenger-vehicles on the 5-foot 6-inch gauge was less than three times the gauge, but on the metre gauge it was nearly three-and-two-thirds times the gauge. The longest rigid wheel-base for goods-vehicles on the 5-foot 6-inch gauge was a little more than twice the gauge, but on the metre gauge it was more than three times. The extreme overhang of the vehicles on each side beyond the gauge was less than half the gauge for 5-foot 6-inch lines, whereas for metre-gauge lines it was more than

three-quarters of the gauge. Any difference in the conditions allowed for vehicles of the two gauges ought to have been in favour of the standard gauge as having the wider base, rather than the reverse, as at present. To such an extent were those dimensions adverse to the 5-foot 6-inch gauge that Mr. Thomas Robertson, the Special Commissioner for Indian Railways, stated in his report,[1] that that gauge was handicapped, or worked below its full carrying-capacity, by about 22½ per cent. By a simple calculation it would be found that to render the 5-foot 6-inch gauge vehicles proportional in size to the metre-gauge vehicles their extreme width should be 14 feet 3 inches and their extreme height 18 feet 5 inches. Of course such dimensions were inadmissible; he merely quoted them to show how the metre gauge had apparently been favoured in the matter of dimensions. Although a width of 14 feet 3 inches was inadmissible, there did not seem to be any valid reason why the width of standard-gauge vehicles should not be increased to 12 feet, the only necessary alteration to fixed structures being apparently that of the passenger-platforms at the more important stations, which could be effected at a comparatively small cost. He thought that was evident from the Author's diagrams (Figs. 7 and 8, Plate 2). In that way an increase of 14 per cent. would be obtained in the carrying-capacity. He had always held that, of all the principal factors influencing the cost of a railway, the gauge was perhaps the least important. The construction of light standard-gauge lines for the sake of economy had been looked upon in certain quarters as a compromise combining all the evils of both gauges and the advantages of neither; but it should be remembered that the original railways in England were light lines. The first rails laid on the Liverpool and Manchester railway weighed, he believed, only 35 lbs. per yard; and Sir John Hawkshaw, speaking at the Institution in 1851, said that the rails on the Preston and Wyre railway, which had been laid about 12 to 14 years, weighed 42 lbs. per yard; so that home railways as they now existed were simply the development of the original light lines. In order to define what he meant by a light standard-gauge railway he could not do better than instance the Northern railway of Ceylon, 199¼ miles in length, which had lately been built under the direction of his firm, Messrs. Gregory, Eyles and Waring. On that line all the main dimensions of banks, cuttings, etc., were the same as on the main lines of the colony, and the bridges were strong enough to carry the heaviest loads on the main line.

Mr. Wart

[1] "Report on the Administration and Working of Indian Railways." London, 1903.

Waring. The cost of that line per mile, including Rs.1,289 spent out of railway funds on extraneous works which formed no part of the line, was Rs.54,259, equal, at the current rate of exchange of Rs.15 per £1 sterling, to £3,617. The only differences from the standard lines in the colony were the substitution of a lighter permanent way, the omission of passenger-platforms at the less important stations, and alterations in fencing and in a few other non-essential features. The works were light, large bridges and stations were few and far between, and the land was mainly Crown land. That this line was fully able to carry axle-loads of engines sufficiently powerful to work all anticipated traffic for some time to come was proved by the fact that the cost of maintenance of certain sections, which had been open for some years, was very low. The cost of this line might be contrasted with that of the Kelani Valley and Uda Pussellawa lines in Ceylon, of 2-foot 6-inch gauge, also built under the direction of his firm at the same time; on these much of the land was in private hands, while the stations and bridges were nearer together and larger than on the Northern line. The Uda Pussellawa line was built for two-thirds of its length at the edge of a public road, which was stipulated to be kept open for other traffic. The cost of the Northern line might also be contrasted with the cost of the Kalka-Simla 2-foot 6-inch gauge line. Particulars of the cost of these were given in the annexed Table, which, he thought, bore out his views as to the small influence of the gauge upon the cost of a line. With regard to the state of affairs in India, and the remedy, the Author mentioned specially the Rajputana-Malwa and South Indian lines as metre-gauge railways whose traffic had surpassed their capacity as single lines; but if the gross earnings per mile could be taken as any criterion—as the rates charged on all the railways in India were practically the same—it would seem that the Burma and Eastern Bengal railways were in much the same situation. From the Author's Table II it appeared that, when a metre-gauge line
13·3 earned more than about Rs.200 per week gross, the traffic had nearly surpassed its capacity as a single line. From the Administration Report for 1904 Mr. Waring observed that on all the 5-foot 6-inch gauge railways in India the earnings exceeded that amount, and the conversion of these lines to the metre gauge would therefore involve doubling the track throughout. The problem might be divided into three parts. First, how to provide additional accommodation for the South Indian, the Burma, the Rajputana-Malwa and the Eastern Bengal metre-gauge lines; secondly, how to facilitate the concentration of rolling stock at any important point; and thirdly, the future policy of the Government. In his opinion, the best and

COMPARISON OF DETAILED COST PER MILE OF THE NORTHERN RAILWAY OF CEYLON (LIGHT 5-FOOT 6-INCH GAUGE) WITH CERTAIN 2-FOOT 6-INCH GAUGE LINES IN CEYLON AND WITH THE KALKA-SIMLA 2-FOOT 6-INCH GAUGE RAILWAY. Mr. Wari

Description.	5-Foot 6-Inch Gauge.	2-Foot 6-Inch Gauge.		
	Northern Railway. 199¼ Miles.	Kelani Valley Railway. 48 Miles.	Uda Pussellawa Railway. 19 Miles 21 Chains.	Kalka-Simla Railway. 60 Miles.
	Rupees.	Rupees.	Rupees.	Rupees.
Preliminary	..	..	..	1,665
Earthwork, including felling trees and clearing land	5,434	13,927	8,915	169,491
Bridges, culverts, etc.	9,623	30,054	7,503	10,755
Retaining-walls	..	..	645	..
Permanent way, including timber sleepers	24,336	24,657	26,365	20,776
Fencing	301	..	85	1,325
Level crossings, including metalling and gravelling roads . .	329	1,065	1,636	
Stations	2,534	6,875	11,137	18,400
Electric telegraph	613	885	308	..
Land and compensation . . .	1,002	7,155	6,690	1,219
Engineering and administration .	2,757	5,950	3,713	19,050
Rolling stock	4,999	15,827	12,752	21,266
Plant	..	..	..	3,546
Miscellaneous works	862	839	1,715	4,032
Contingencies	180	5,239	4	..
Interest during construction . .	..	..	..	18,601
Maintenance	..	..	..	3,592
Total cost per mile . . £.	52,970 3,531	112,473 7,498	81,468 5,431	293,718 19,581
Extraneous charges not connected with the railway but paid out of Railway Funds	1,289		4,370	
£	54,259 3,617		85,838	
Gradients	1 in 132	1 in 80	1 in 23·8	1 in 33
Minimum radius of curves . .	1,260 feet	236 feet	80 feet	120 feet
Weight of rail	46½ lbs.	46½ lbs.	46½ lbs.	41½ lbs.

most economical solution, as meeting all requirements, was to do away with the metre gauge altogether; but that, according to the figures given in the Paper, would cost nearly £32,000,000; and as he did not suppose the Government of India were likely to undertake so large an expenditure, he would suggest the following palliative measures. It would be observed that the Southern Marhatta, the Haidarabad-Godavari, and the South Indian railways, were altogether isolated from the rest of the metre-gauge lines of India, and therefore the first step was to construct a metre-gauge line between Khandwa and Hotgi, a distance of about 300 miles. The lines in the

Mr. Waring. south of India would thus be placed in connection with all the other metre-gauge lines, even as far as the eastern corner of Assam, and the quantity of rolling stock that would be available for concentration in an emergency would be at once increased by about 50 per cent. There were now only 1,045 engines, 4,413 carriages, and 23,645 wagons on the metre gauge available for concentration. The construction of that one line would render available at once 1,519 engines, 6,438 carriages, and 31,823 wagons, for concentration at any part of India. Then he would convert the main line of the Rajputana-Malwa railway between Ahmedabad and Delhi to the broad gauge, doubling the rest of it: this alteration would place the Jodhpur-Bikaner lines somewhat at a disadvantage by interfering with their connections; but by building a short metre-gauge line between Merta City and Ajmere that connection would be restored. He would convert the South Indian line to the broad gauge, because if the railway connecting India and Ceylon by way of Adam's Bridge were ever built, the whole of the South Indian lines would then be placed in direct communication, by way of the Ceylon 5-foot 6-inch gauge lines, with Colombo, which, from its geographical position and from the amount of money that had been spent on the harbour, was justly entitled to be the port for Southern India. He would double the Burma railways, because they were completely isolated from all the rest, and if ever linked up the connections would be with the metre-gauge lines of Assam or of the Federated Malay States. He would also double the lines in Eastern Bengal, because they were connected with the metre-gauge lines in both directions, his alternative policy being to ultimately confine the metre-gauge lines to the districts north and east of the Ganges. When the time came, as the traffic increased he would convert the Southern Marhatta, the Haidarabad-Godavari, the Khandwa-Hotgi, the rest of the Rajputana-Malwa and the Jodhpur-Bikaner lines to the 5-foot 6-inch gauge, and in that way he would eliminate the whole of the metre-gauge railways from the rest of India. Holding the views he had expressed, Mr. Waring strongly deprecated the present system of allowing lines of 2-foot 6-inch and 2-foot gauge to be constructed at isolated points all over the country. They might be suitable for exceptional cases, such as the Darjiling and Simla lines, and the railways of that gauge in Ceylon; but as now being built in India they formed the nuclei of a system which might in a few years be as difficult to deal with as the metre-gauge lines were now admitted to be, and any trifling economy in capital cost of construction, taking into account the working-cost of break of gauge, would have been much too dearly bought. The questions raised in the Paper appeared, on account of the rapid

growth of the railway system, to be of an urgent nature, and the adoption of a definite policy was on that ground essential. In conclusion, he advocated the construction of a 5-foot 6-inch line from Palanpur via Deesa to Badin south-east of Haidarabad in Sind. This line appeared to him to be of great strategic importance as effecting the great saving in distance shown by the following figures, between Bombay and Karachi, and Bombay and Sukkur :— Mr. Waring

APPROXIMATE DISTANCES.

	Miles.
Bombay to Delhi (via Itarsi, Bhopal and Jhansi)	880
„ „ „ („ Ajmere, Phulera and Rewari). . .	860[1]
„ „ Sukkur (via Rajputana-Malwa Railway, Bhatinda and Samasata)	1,460[2]
„ „ „ (Broad Gauge via Itarsi, Jhansi, Delhi and Bhatinda)	1,480
„ „ Karachi (Broad Gauge via Itarsi, etc.) . . .	1,770
„ „ „ (via Marwar, Barmer and Haidarabad) .	950[2]
„ „ Sukkur „ „ „ „ „ .	1,030[2]
Bombay to Karachi (by proposed new broad-gauge line via Deesa, Badin and Haidarabad) . .	800
„ „ Sukkur (by proposed new line)	880

[1] One break of gauge. [2] Two breaks of gauge.

Mr. C. O. BURGE considered that the question was, how to remedy what was originally a great mistake; and that the text of the discussion was best expressed by the following passage in the Paper: "At no time has there been any serious attempt to lay down an inexpensive standard-gauge line equipped with suitable light rails, rolling stock and station-accommodation." Why had not that been done? The Author's answer was found in the few words preceding the foregoing sentence: "Although the Government Administration Report on all the railways in India gives the cost of the standard- and metre-gauge lines as £10,666 and £5,133 per mile respectively, the difference in capital cost affords ample justification for the early policy of adopting the smaller gauge: had it not been allowed, about 5,000 miles of the present railway-lines would probably not now be in existence." With regard to that statement, Mr. Burge found that the 11,421 miles of narrow-gauge line at £5,133 cost in round figures 59 millions sterling, and as the Author said that 5,000 miles less would have existed if the broad gauge had been substituted, there would have been 6,521 miles of broad gauge costing the same amount, 59 millions. On that basis, the cost would have been £9,173 per mile for the light broad-gauge lines while the main lines only cost £10,666, a difference of a little more than Mr. Burge. p. 8

Mr. Burge. £1,000 per mile between the main lines of India and the light subsidiary lines. He had intended, having had much Indian experience, to go into some detail with regard to the difference in character between the main lines and the subsidiary lines, but that had been done so amply by the preceding speaker that further comment was unnecessary. He would only say in corroboration that in New South Wales, where he had been engaged in recent years on the construction of railways, there was a great difference in cost between the main lines and the subsidiary branch lines. The main lines of that colony, 2,325 miles in length, had cost on an average £13,952 per mile; they were all built in main-line fashion with large engine-stations, goods-stations, etc. The subsidiary lines, of the same gauge but built in a much lighter fashion, had cost £3,303 per mile for 814 miles; in fact, one line of 60 miles had cost less than £2,000 a mile. The experience in Victoria was the same. The present Engineer-in-Chief of the Victorian railways had shown [1] that 5-foot 3-inch light lines were built there extensively for between £2,000 and £3,000 per mile. Therefore it seemed extraordinary that the Author should give such a high figure for the cost of light broad-gauge lines in India. Mr. Burge's own experience bore out what had been said by many of the leading engineers in the last discussion on this subject, and although most of those engineers had not been in India, they had connections with India sufficient to render their views authoritative. Sir John Hawkshaw, for a long time the Consulting Engineer of the Madras Railway, had given the difference between a narrow gauge and a broad gauge of the same carrying-capacity—which was the great point—as £360 per mile; Sir John Fowler had put it at £633, Sir George Bruce at £200, and the mean of Sir Guilford Molesworth's figures was £425. In Victoria, where the calculation had been made very carefully, it had been put down as £261; and in South Australia, where there were two gauges, £350 had been given. As to the question of demurrage, experienced traffic-managers knew the value of time as regarded trucks, and that it was almost impossible, where loading and unloading took place at a change of gauge, to have always the corresponding numbers of trucks meeting. With regard to what might be called, for want of a better word, the fluidity of the rolling stock, in New South Wales the gauge was uniform, 4 feet 8½ inches; but the seasons were quite different in the north of the colony from what they were in the south, and consequently the movements of grain and wool varied so much that a considerably

[1] M. E. Kernot, "Economical Railway Construction in Victoria." Minutes of Proceedings Inst. C.E., vol. cxxix. p. 280.

smaller quantity of rolling stock served the country than would suffice if there were two or three gauges. When the pressure began at one end of the colony it left the other. In India such facilities did not exist to any large extent: that point was emphasized by recent news of a large shortage of trucks for the coal-traffic in India, which was carried mainly on broad-gauge lines. It would be interesting to know whether the cost of that single mishap would not be equal to a great deal of the saving by the reduction of the gauge. It had been urged by the advocates of narrow-gauge lines that there would be a great saving in dead weight. But that had entirely disappeared. From the Tables given by the Author it would seem that the proportions on the two gauges were practically the same, due, of course, to the fact that so much of the loading was of low specific gravity. Goods of which 110 cubic feet went to the ton constituted about the maximum loading of a 5-foot 6-inch wagon, the corresponding figures for the normal gauge and for the metre gauge being 93 cubic feet and 75 cubic feet respectively. Therefore it was impossible to utilize fully the weight-carrying capacity of a small wagon with a large portion of the ordinary traffic found in India, such as cotton, skins, etc. In corroboration he might point out that in a particular year—which he had selected because the mileages were nearly the same—the ton-mileage of New South Wales (having the normal gauge) was three times the ton-mileage of Queensland (having the 3-foot 6-inch gauge), and the cost of the rolling stock to serve that traffic was three times as much in New South Wales as in Queensland. There was therefore, as a rule, no advantage whatever in the narrower gauges in regard to dead weight. The late Sir Charles Hutton Gregory, Past-President, had told Mr. Burge when sending him out to the Cape that he had done his best to persuade the Cape Government to continue the 4-foot 8½-inch gauge they had already begun, but without effect: new railways were built on the 3-foot 6-inch gauge. Twenty years later, when the 3-foot 6-inch gauge had been continued to Johannesburg, and an agitation arose for an even smaller gauge, the General Manager of the Cape Government Railways wrote in his Report: Mr. Burge.

"There has been considerable agitation on the subject of the laying of light railways during the last few years. I see no reason for changing the opinions I expressed in 1891 and in 1892 on this subject, and I trust that Parliament will gravely consider the probable effect of the introduction of a narrower gauge than that of our own railways before authorizing such a breach of gauge. If the gauge originally adopted had been 4 feet 8½ inches instead of 3 feet 6 inches the journey from Cape Town to Johannesburg would be performed in about half the present time. The effect of such a saving of time on the passenger traffic would have

Mr. Burge. been enormous. But if the present gauge is to be still further reduced what will posterity think of the foresight or want of foresight in adopting a standard that limits the speed and carrying capacity of the train? When the traffic is not expected to be heavy I see no reason why railways should not be constructed with less ballast than a standard line. When the traffic improves the line could be better ballasted and prepared for quicker speeds and heavier loads."

There was a slight mistake in this passage, because the original gauge was 4 feet 8½ inches; but the writer of it was referring to what was determined subsequently. It seemed deplorable that a great country like Africa was about to be penetrated from north to south with a gauge of 3 feet 6 inches. Central Africa was being looked to for the future cotton-supply. Cotton was very light—just the load fitted for a wide gauge; and yet the line had been projected beyond the Zambesi River to Lake Nyanza, and through to Cairo, on a miserable 3-foot 6-inch gauge. It would be found that the steamship-companies, who were progressing faster than the railway-projectors, would carry passengers from north to south of Africa much more quickly by steamer than the railways could on a line of 3-foot 6-inch gauge. The conclusion he had come to was that ultimately conversion was the only proper course, though it would take a long time. If the Government of India had done it in the first instance, it would have been done, according to the figures of the Author, for about 4½ millions more than the Government had spent up to the present. Now conversion would cost about 32 millions sterling. He hoped the Institution would give no uncertain reply to the question which had been put before it by the Author in a very moderate and impartial manner.

Sir George Bruce. Sir GEORGE B. BRUCE, Past-President, having been present at the discussion in 1873, remembered well how keen were the arguments used upon both sides nearly 33 years ago. His own estimate for the difference in cost between a broad- and a narrow-gauge line, namely, £200 per mile, which had been quoted by the last speaker, was less than some of the other estimates given by engineers at that time, probably because he had been accustomed to work in Madras, where the earthwork was done for 1*d.* per cubic yard instead of 1*s.* per cubic yard paid in other parts of the country to English contractors. The discussion on that occasion dealt with the desirability of securing uniformity of gauge and with the enormous disadvantage to traffic of having a break. All the engineers spoke strongly on that point. Then came the question what the cost would be, and the sum laid down was very large, being based upon the misconception that the width of the gauge was the element which regulated the cost of the line. It did nothing of the kind. With a coach of given width,

nothing was gained by putting the wheels closer together and having a large overhang outside the bearing. The difference was accounted for by the different conditions upon which the lines had to be constructed. If the 5-foot 6-inch line were constructed with 82-lb. rails and the metre-gauge line with 40-lb. rails, if there were large stations in the one case and small stations in the other, and if everything on the smaller gauge were reduced to the least possible dimensions, of course the difference would be large; but that difference was not due to gauge. As Mr. Waring had pointed out, that was not the way in which the English railways had been made in the first instance. They began as very light lines, and as the traffic grew so the weight of the permanent way, as well as the size of the carriages, and the station-accommodation and workshops increased. It was not the gauge that necessitated the increase of cost, but the increase of traffic on the line. Increased accommodation in workshops, etc., was only necessary when the rolling stock became large. It was a fallacy in 1873, as it was still, to compare the two things in that way. As Mr. Barlow then indicated, heavy traffic necessitated the provision of large sidings. The traffic on broad-gauge lines was much heavier than that on the narrow-gauge lines; the heavy traffic required the more costly form of construction, the other did not. As he had mentioned in the Institution before, about the year 1842 he was looking after some engines that were being put down under Stephenson on the Grand Junction railway between Liverpool and Birmingham, and the contractor for the maintenance of the permanent way objected to the engines because they weighed 16 tons, and an effort had to be made to reduce their weight. Now, engineers thought nothing of 16 tons on one axle. The railway in question was a line of 4-foot 8½-inch gauge which had since been carrying engines as large as any in the kingdom. That was the proper way to develop. He agreed with the last speaker that the right thing to do was, as quickly, quietly, and modestly as possible, to make a change. He did not think it would cost anything like the 35 millions mentioned. The proper step was to get rid of the narrow gauge; it had done and was doing good work, but it involved an unavoidable element of weakness, and break of gauge should not be allowed to interfere with the development of traffic all over the country. When a narrow-gauge line reached the limit of its capacity, the best plan was to put a broad-gauge line alongside, make that the second line, and widen the other as quickly as possible. That might be a counsel of perfection, but he thought perfection should be aimed at. A great country like India ought to have the best, and he believed that the course he had outlined was the proper one,

Sir George Bruce.

Sir George Bruce. that it would be a great success, and that not only would it not ruin the country, but it would do an immense amount of good and set a good example. The cardinal error had been made at the beginning in fixing upon a gauge of 5 feet 6 inches, and thus setting people thinking how to devise something cheaper.

Sir Henry Kimber. Sir HENRY KIMBER, Bart., M.P., remarked that, not being an engineer, he would not enter into the question from the engineer's point of view; he looked at the subject rather as one in which the problem had reached such a stage, from the commercial point of view, as to render the engineering questions involved, although they were serious, of secondary importance. The question now at issue was not—as it had been in 1873—what should be the gauge of railways in India; had it been so, he might have said something rather adverse to the metre gauge, although he was the chairman of a company whose system consisted entirely of metre-gauge lines. But that stage had been passed by at least 30 years, and a state of affairs had now been arrived at in which there were two principal gauges far advanced, and two minor gauges, which were still advancing and doing good service. The question was put by the Author in a threefold form: first, whether the standard gauge of 5 feet 6 inches, which was represented by no less than 15,000 miles of line in actual working, should be converted to the metre gauge; secondly, whether the metre gauge, which was represented by 12,000 miles of line in actual working, should be converted to the standard gauge; and thirdly, whether both should be altered to some other gauge, preferably the 4 feet 8½ inches of Great Britain. What were the material facts with regard to the first question? First of all, did they yield satisfactory results when subjected to the test to which all undertakings had to be submitted, namely, good paying work upon the capital involved, and work which was for the good of the community in which the line was established? It was shown clearly in the Paper that the standard-gauge lines paid a return upon capital, which was the first important point. That might be a sordid way of looking at things, but still it was the test to which engineers, at all events, always submitted projects of public utility. If a railway line paid a good return upon its capital, it might be assumed that the country in which it was worked also profited, otherwise it would not be used. What were the reasons for altering that state of things? The standard-gauge system had cost in round figures 150 millions sterling, and at present it was paying well. To alter it would reduce its carrying-capacity, which meant its earning-power. It seemed to him that those facts were conclusive against alteration of the standard gauge to

Sir Henry Kimber.

narrow gauge. But a further argument was the fact that the alteration would involve, according to actual experience, the expenditure of a much larger amount of capital than would be likely to furnish a return. He took it at about £4,000 per mile—though probably members of the Institution might be able to show how to do it for less, if the work were undertaken as a whole. But putting the cost even at £3,000 per mile, on 15,000 miles that was 45 millions sterling. Was it likely, on any reasonable estimate based upon the present earning-power and carrying-capacity, that the standard-gauge system reduced to the metre gauge would pay not only upon its existing capital of £12,000 per mile, but also upon an additional £3,000 to £4,000 per mile? For those reasons he dismissed from further consideration the first branch of the problem, and he would certainly vote against the reduction of the standard gauge to the metre gauge. For similar reasons he would vote against its reduction even to a 4-foot 8½-inch gauge. The next branch of the problem dealt with the alteration of the metre gauge to the standard gauge, and the first part of his argument would apply almost equally to that. It had cost, say, £5,000 per mile for the 12,000 miles, which was 60 millions sterling. On that capital it paid a dividend; and the country derived from the use of the railway a profit which made it worth while to use it and to pay a fair return upon its capital. His own company (the South Indian Railway Company) paid, and had paid for some years, 7½ per cent. on the whole of the capital. Not the least of the benefits it was able to show was £140,000 per annum of actual profit, which was paid into the Indian Exchequer, upon British money used in the form of the Secretary of State's capital, over and above the 3 per cent. on capital cost. Therefore it could be claimed that the metre-gauge system paid, and that the Company was doing not only reproductive work in the sense of paying an ample return on the capital, but also a service to the people of India which was beyond price. The cost of conversion was variously taken, upon the basis of specific cases, as being between £2,800 and £4,100 per mile, but he believed that it would not cost more than £3,000 per mile, which for 12,000 miles would be 36 millions sterling. No doubt it would increase the carrying-capacity and the earning-power, and there had been cases in actual practice in which it had been found expedient to do this; but he did not wish to deal so much with individual and local cases as with the general subject for the whole of India, which he imagined was the object of the Author. The third branch of the problem had still to be considered, namely, the alteration of both gauges to 4 feet 8½ inches.

Sir Henry Kimber. For some years, while the alteration was taking place, costly operations would be going on, upon which no return could be expected until the work was completed, and those operations would dislocate more or less the traffic of 200 millions of people. The Author himself, after stating the problem in that threefold form, rather reduced it to one of smaller dimensions, because he said that the question now was whether it would be better in the present condition of the system of Indian railways to substitute a single standard track or to double the metre-gauge lines. He was getting closer to his subject there; but, with great deference to him as a man for whose judgment and experience Sir Henry Kimber had profound respect, he thought perhaps the Author left the reader in some confusion. Did he abandon the threefold problem of conversion altogether, and propound this further question in reference to future construction only? On p. 8 the Author said that confusion would increase from year to year unless some more definite policy was adhered to than that which had been followed during the last 30 years. That Sir Henry took to be the main object of the Paper. The question then reduced to a twofold problem, namely, whether a single standard gauge should be substituted for the two existing systems, or whether the metre-gauge lines should be doubled. In another part of the Paper it was shown clearly that doubling a metre-gauge line would increase its carrying-capacity four or five times at least, and Sir Henry believed that was right. Not only was the carrying capacity of a mile of line increased, but the speed was also increased when the track was doubled; and he thought the advantage which was obtained by doubling a track had never been appreciated at its real value. The proposal to substitute a single standard-gauge track was only another way of putting the second part of the first problem—changing the metre gauge to the standard gauge—of which he had already disposed. The question of doubling the (metre-gauge) track for about 15 miles out of Madras to Pallavaram would shortly come before the Board of the South Indian Railway Company. The question of doubling always arose first at termini: suburban traffic sprang up, and the track was doubled for a few miles; in time that would be extended, and so the system would grow. But each gauge would grow as a single track in the first instance, and it would be many years before local traffic justified the doubling of either throughout. Therefore he considered that the best policy for India as a whole was to let the two gauges continue to grow. They had grown to a point at which they were profitable, they were doing good service to the population, and they paid interest upon the capital. As they advanced mile by mile,

Sir Henry Kimber.

whether on the standard gauge or on the metre gauge, they were paying their way, and that was a very important point. The policy for the whole of India was always subject to variation in dealing with particular cases in a special manner, but he hoped to see the day when that general policy would be adopted. Both systems were plants of strong growth, yielding fruit: let them both grow according to the exigencies of the time, year by year, and mile by mile. The metre gauge and the standard gauge would penetrate throughout the whole of India, and all the large centres of trade and termini would in time be connected by the metre-gauge as well as by the standard-gauge system. Meanwhile, engineers should apply their inventive powers to the provision of mechanical facilities for exchange of traffic at points where transhipment was necessary; there was room for great improvement on existing arrangements. The effect would be remarkable in one way. In times of emergency, such as military exigencies, that plan would give the advantages of through double tracks, one line being made an up line and the other a down line. Already the difficulty of want of speed with the single track had been met in times of famine by making it an up line for 3 or 4 days together, with no return traffic. Both systems should ultimately meet at all terminals and at the coal-fields, and should tap the ports and the large presidency towns. The same problem was cropping up in Natal; there was a single line 500 miles long into the Transvaal, and the question was being debated whether it should be doubled, or whether a second line should be built opening up a different country, but still reaching both terminals of the first line, with intermediate branches touching the capital, Pietermaritzburg, and any other important centres; so that these centres would be connected, and there would be an up and a down line, yet with only the expense of a single track in each case. India was a vast country. The railway-authorities had already been authorized, almost ordered, by the Government, to make lines in Southern India which competed with lines they had already made; and although they looked rather askance at it, he believed the policy of the Government was correct in allowing those lines to be made, because they opened up fresh country. He thought that what he had put forward would be a sufficiently definite policy to aim at; it would allow the two systems to grow; it would be not only letting well alone, but improving upon it; and in the ultimate result he believed a state of affairs would be arrived at which would afford all the benefits of double tracks, with greater strategical value in times of emergency, such as military difficulties or famine. He had been much interested in the remarks of the engineers who had already spoken in the discussion, yet it seemed to him as a commercial

Sir Henry Kimber. man that they had dealt with subjects requiring attention in the execution of a project when resolved upon, rather than with the primary discussion of the policy to be adopted.

r Guilford oleaworth. Sir GUILFORD MOLESWORTH, K.C.I.E., Past-President, observed that he had lately been told that there was a general impression among engineers that he was the father of the break of gauge in India; and he wished to repudiate emphatically the paternity which had thus been thrust upon him. Before going to India he had successfully resisted the break of gauge in Ceylon, and after that he wrote a strong memorandum to the Secretary of State for the Colonies exposing the fallacies which had led to the craze for exceptionally narrow gauges; and he had every reason to believe that his antagonism to the break of gauge was the cause of postponing his appointment as Consulting Engineer to the Indian State Railways for more than a year, pending the settlement of the gauge question. As soon as he arrived in India, Lord Mayo, the Viceroy at that time, said to him, "I wish you distinctly to understand that the question of the gauge of railways has been settled, and must not be re-opened." Although he considered the break of gauge in India to be a very mistaken policy, it had frequently fallen to his lot to take up the cudgels for the metre gauge, and to defend it from the intemperate and unfair arguments of its opponents. He had nothing to say against the metre gauge as a gauge, but he did think that the standard gauge was better suited than the metre gauge to the bulky agricultural traffic of India. The Author rightly did not claim that an exact comparison could be made on the statistics he gave, because the conditions varied. Statistics, like mathematics, were valuable tools when rightly used, but when used without a complete knowledge of all the facts affecting the case, they were apt to cut in the wrong direction. He had been confronted over and over again with the misuse of statistics, more especially with regard to the gauge question. Looking back on all he had said and written on the question, it was possible that he himself might have misused statistics unconsciously. He had no recollection of having estimated the difference of cost between the standard and the metre gauge as being about £400 per mile, as mentioned by Mr. Burge; but if he were rash enough, after the experience he had had, to make an estimate now, he would put it at a much lower figure. He had made no pronouncement upon the subject since about 24 years ago, when the Government of India asked him to formulate some general idea of the difference between the cost of the two gauges. He replied that it was simply impossible to lay down anything like a ratio; it would differ in every case. He brought

Sir Guilford Molesworth.

forward some extreme figures to show that impossibility, and to his astonishment, he discovered 2 years later that a witness, giving evidence before a Railway Committee in the House of Commons, named him as the author of the ridiculous statement that the difference of cost between the standard and the metre gauge was 5 per cent. in mountainous country, and 33 per cent. in the plains. He afterwards traced that mistake to an officer of the Royal Engineers who had read his note carelessly, and had utterly misapprehended it. Anyone taking up the Author's Tables and, without knowledge of the actual facts, looking at the averages, would come to the conclusion that the respective costs of the two gauges per mile were about £11,800 and £4,750; but it was scarcely necessary to say that such a conclusion would be absolutely misleading. The railway history of India might be divided into two epochs, one beginning about 1850, and the other about 1870. All the metre-gauge railways in Table II (p. 17) had been made during the latter period, and six out of the eight standard-gauge railways in Table I had been made in the earlier period, when the conditions affecting capital cost were absolutely different. The change of currency in 1873 completely altered the purchasing-power of the English monetary standard to an extent varying between 30 and 50 per cent. Next, the high rates of guarantee formed a sort of premium on the increase of capital account. Further, the capital of a railway always increased with its age, and the railways of the earlier period were about 20 years older than the metre-gauge lines. Lord Lawrence had drawn attention to that fact in a Minute of 1870. He then said that he regarded this danger with great concern; and that if the Government was to avoid it, some means must be found of putting an effectual stop to the insidious growth of the capital on the old lines. Before Sir Guilford Molesworth went from Ceylon to India, with the view of checking inflation of the capital account, he closed that account for the Ceylon railways, with the happiest results; and in India he had endeavoured to carry out, as far as possible, the same principle of checking the inflation of the capital account on the metre-gauge State railways, by meeting the minor additions to the line from revenue. Although that principle had been admitted to be sound, it had been abandoned after a time to a certain extent, owing to the difficulty caused by comparisons, made in England on crude statistics, between the working-expenses of State and guaranteed railways; and he had been accused—he admitted with some justice—of having damaged the State railways in the eyes of the Home Government by pressing this policy. Another cause of the higher cost of the lines built in the earlier period was the

r Guilford Molesworth. difficulty of keeping down the capital account. Lord Lawrence had stated that much of the wasteful expenditure incurred in connection with the Indian railways had been fully pointed out, before it was too late to stop it, by the Government officials; but that these officials had not on all occasions been supported by the Government in their attempts to enforce economy. Again, all the railways of the earlier period had been constructed under lucrative contracts, while the later ones had been constructed chiefly under departmental supervision. The earlier railways had a very expensive type of permanent way, and very heavy rails; while the later railways had had the advantage of improvements in design and execution of works, cheaper bridgework, and the substitution of steel for iron. Lastly, the premium paid upon the purchase of the guaranteed railways had added immensely to their capital; in the case of the East Indian railway it had added £3,000 per mile to the capital cost. Those facts showed that the earlier railways must be put out of court for any comparison with the metre-gauge railways of the later period. Eliminating those, there were left for comparison only the Bengal-Nagpur and the North-Western railways. He was not personally acquainted with the Bengal-Nagpur railway, with the exception of the first 145 miles, which had been converted from metre gauge to standard gauge, and therefore he could not speak with any great authority; but he was aware that the country traversed necessitated the construction of many tunnels, and there were some very formidable rivers to be crossed. Therefore he did not think it could be fairly brought into comparison. But he had an intimate acquaintance with the North-Western railway, and the very heavy works on that line would quite shut it out from a fair comparison, unless about 50 per cent. were deducted from its capital cost. First of all, the railway crossed gigantic rivers flowing from the Himalaya mountains. The Sutlej, the Beas, and the Jumna, whose three bridges aggregated 2½ miles in length, had many of their piers washed away almost immediately after the railway was open for traffic. The three great bridges over the Ravi, the Chenab and the Jhelum, aggregating about 3 miles in length, with extremely expensive training-works, had been first constructed on the metre gauge, and had afterwards had to be reconstructed on the standard gauge, at considerable cost. In addition, the Sutlej had been bridged twice, and the Jhelum once, the lengths of the three bridges aggregating about 2 miles; while the Indus had been bridged three times, once with a very expensive cantilever bridge. There was also an immense amount of heavy work in mountainous country, and not only a temporary, but also a heavy permanent

Sir Guilford Molesworth

line up the great Bolan Pass. Between Sibi and Pishin there was a very heavy country, including the great Chuppa Rift, the Mud Gorge, and several other heavy works. Beyond that the great Amran range had to be crossed, with a tunnel 2½ miles in length through the Khojak Pass. The railway between Jhelum and Pindi was in very broken country, involving heavy work, which was immensely increased by the fact that the line was first built on a gradient of 1 in 50, contrary to his advice, and was afterwards re-graded, involving almost the building of a second line, through the heaviest part of the country, at a very heavy cost. The cost of that line had also been increased enormously by its being a work of emergency undertaken during the war, his instructions to the Chief Engineer at that time being: "You will have *carte blanche* as to money; you will act upon your own responsibility so as to avoid waste of time by unnecessary reference; and the only limits imposed upon you are, not to interfere with the military movements on the trunk road, and not to take carriage from the military transport department." There was also heavy work in the tunnel through the Margalla Pass, and a large number of temporary lines had been made where permanent lines were necessary, especially on the banks of the Indus, where there were a good many tunnels and rock cuttings. Again, the line between Jhelum and Pindi, and in the Indus Valley, had been begun as a metre-gauge line; that between Lahore and Pindi had actually been opened for traffic as a metre-gauge line, the construction trains of the standard-gauge line running side by side with the metre-gauge traffic. All those facts, he thought, justified the view that unless the cost per mile, which was put down as £9,600, was reduced by 50 per cent., it would not be fair to bring it into comparison with the metre-gauge lines. The cost of the light standard-gauge line in Ceylon had been given by Mr. Waring as about £3,600 per mile. For the extension of the Nizam's railways the cost was a little more than £3,000 per mile, with rails weighing 66 lbs. per yard, and steel sleepers; but this capital cost had been more than doubled by the premium on the sale of the original line by the Nizam's Government to the company. With regard to the Ceylon light line, a curious comparison had been made. The standard-gauge line cost only about half as much as the 2-foot 6-inch gauge line. The cost of permanent way and sleepers, including laying, was only £45 per mile more than for that of the 2-foot 6-inch gauge, but the rolling stock for the 2-foot 6-inch gauge cost £600 per mile more than that of the standard gauge. With regard to the returns on capital shown in the Author's Tables, Sir Guilford Molesworth thought he had demonstrated that the cost of the standard gauge had been put far too high for the purpose of

Sir Guilford Molesworth. comparison, in consequence of inflation of capital and other conditions; the returns on capital ought therefore to be far higher than was indicated by the averages in the Tables. The other items in the Paper were not affected by the capital cost, and he thought the Author had fully established the conclusions he had summed up on p. 9. He could not agree with the Author that, had the metre-gauge policy not been allowed, about 5,000 miles of the present railway-lines would probably not be in existence. If a light standard gauge had been adopted, with rails capable of taking the ordinary standard-gauge carriage- and wagon-stock, it would have cost India less than it had done, because the initial cost would have been very little more, and that little would have been more than counterbalanced by the loss occasioned by changes of gauge, by the loss and expenses of transfer, by the need for additional rolling stock, and by the cost of construction of lines necessary to link together the several systems. The evil of the break of gauge had now advanced too far to leave room for any hope that unity of gauge could be restored to India. He thought the only thing to be done was to minimize the evil as far as possible by restricting it to certain defined areas, and he suggested that two courses were absolutely necessary in the near future. First, instead of doubling the metre gauge, to adopt the practical suggestion made by Sir George Bruce, and put down the second track as a standard-gauge track between Ahmadabad and Agra and Delhi, leaving the metre-gauge track to be widened at leisure. Secondly, to give the metre-gauge system north of the Ganges access to Calcutta by bridging the Ganges, and to construct a metre-gauge double line from the Ganges to Calcutta.

Mr. Shelford. Mr. FREDERIC SHELFORD understood that the Author's motive for presenting the Paper was that the Government of India desired to ascertain the views of the Institution on a problem of some difficulty; and plain advice had certainly been forthcoming, namely, convert the metre-gauge line to the standard gauge as quickly as possible, as the longer it was delayed the more it would cost. He was not sure, however, that the Government of India would be able to adopt that advice, on account of the expense, which had been an obstacle in the past, and would probably be so in the future. It seemed to him that the most likely course of events was that the metre gauge and the standard gauge would be allowed to grow side by side until they covered practically the whole of India, after which the metre gauge would no doubt be converted to the standard gauge bit by bit. He did not think such a development of the railway system of India would be a happy one; for when the metre-gauge lines had been converted to the standard

gauge there would still be a disproportion between the dimensions allowed on the standard gauge and the gauge itself, as well as an unnecessary duplication of lines on the standard gauge all over India. He was afraid India would always bear the marks of the mistakes that had been made in the past. India had come to the Institution to learn something: what could the Institution learn from India? Surely the map (Fig. 1, Plate 2) showed the importance of avoiding at the beginning the introduction of any gauge but the standard gauge. It might seem easy to those who had not had experience of the matter to make laws and regulations to prevent the introduction of any gauge but the standard gauge in a country; but it was not so, as he had found from personal experience. The course of events was often something like the following. A government in a new country might construct a main line of a certain gauge. Five miles off that line there was, say, a mine or an estate desiring communication with the main line. The company working the mine or estate was unable to afford the cost of the construction of a line of standard gauge. The consequence was that it built a branch line 5 or 6 miles in length, of such small gauge as it was able to afford. Five miles farther away there might be another mine or estate, which, desiring to have similar means of communication, arranged with the first company to extend its narrow-gauge line to their property; and very likely a third estate arranged for the same thing. One day the Government discovered that it had a main line of a certain gauge, from which had sprung an important branch of narrow gauge but considerable length, looking as if it were likely to spread over the country. It was extremely difficult to know how to deal with a problem of that sort. The builders of the first small branch generally proceeded on the idea that if they built the line of a small gauge, and it were afterwards desired to convert it to standard gauge, it could be pulled up. But it never was pulled up. Most likely the bridges were strengthened, and the line was adapted to carry heavier loads; but the gauge remained the same. The only solution he knew of in a case of that sort was for the Government to say at the outset, if it was unable to build branch lines itself, that such lines must be constructed of the standard gauge, or of some small gauge which could not extend all over the country. For instance, a gauge of less than 2 feet was not likely to spread very far, because, as the line extended and the traffic increased, it would be found impossible to put an engine on the road that would haul the loads. He was glad to say that in Africa rather better arrangements were being made with regard to gauges. In the British possessions in Africa all the railways were constructed to a gauge

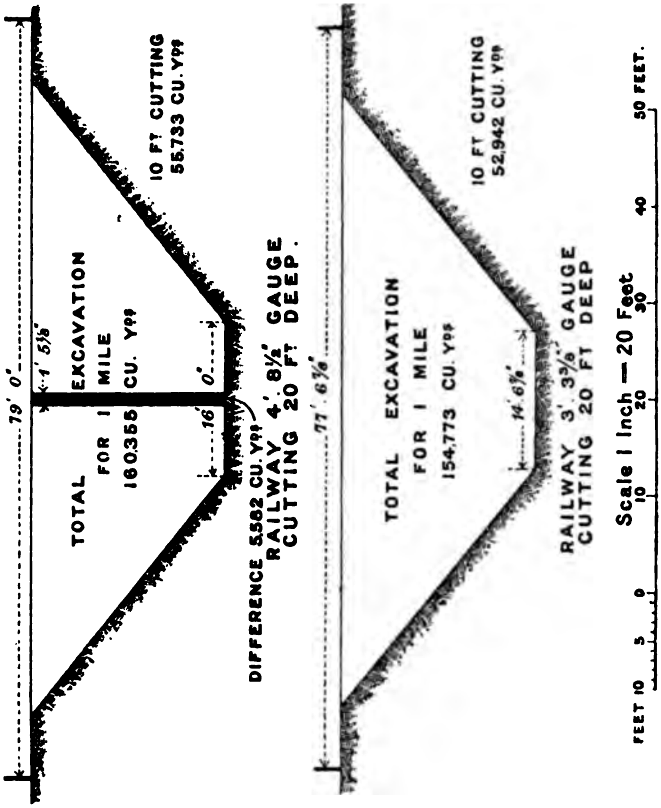
Mr. Shelford

Shelford. of 3 feet 6 inches with the exception of Egypt, which began with 4 feet 8½ inches, but was now extending southward on the 3-foot 6-inch gauge. The gauge of the Sierra Leone Government railway was 2 feet 6 inches, but it was isolated, and likely to remain so for many years to come. The Uganda railway, on the east side of Africa, was on the metre gauge, following Indian practice, but it would be converted to 3 feet 6 inches in due course. Whether 3 feet 6 inches was the right gauge was a matter with which the discussion was not concerned. Mr. Burge had spoken of it in rather a disparaging way, but he might not know that the engines and rolling stock of the present day on the 3-foot 6-inch gauge would have been considered heavy on the 4-foot 8½-inch gauge about 30 years ago.

Mr. Ross. Mr. A. Ross thought it would be generally agreed that break of gauge was a great misfortune to a country, and a serious hindrance to its commercial progress. When a new country was being opened up by a railway it was not so much the existing traffic that had to be taken into consideration as the prospective advancement of the country; and the gauge should be such as would carry the railway through to the end. India had always been a great country; and the fact of the 5-foot 6-inch gauge having been established as a standard showed that the British people had been of opinion that it would be greater still in the future. The evil effects of break of gauge were well known at home at that time. In fact, the battle of the gauges had been fought, and England had established its own standard of 4 feet 8½ inches; and that lead had been followed by Central Europe, the United States, Canada, and other places. It was unaccountable, therefore, that as late as 1873 the Government of India should revert to the metre gauge. In order to demonstrate graphically that the cost of constructing a railway was not proportionate to the gauge, he had placed on the wall two sections of a 20-foot cutting, one for a gauge of 4 feet 8½ inches and the other for a metre gauge. The black perpendicular strip on the wider gauge represented a width of 1 foot 5⅛ inches, the difference between the two (*Figs. 9*). That strip meant only 0·18 acre of land per mile of railway; and the extra road-bed was only 840 square yards per mile. The excavation for a 20-foot cutting on the wider gauge represented only 3 per cent. more than that on the metre gauge; for a 10-foot cutting it would be 5 per cent.; and of course for a surface line there was no excavation to be considered. The sleepers of the wider gauge would be 3 feet longer, but the remainder of the section, the drainage-slopes, fences, etc., would be common to both. He did not give any figures to show the difference in cost, because the conditions in India were different from those at home. It seemed to

him that in a new country it was necessary to have what might be called a pioneer railway, and that pioneer railway should be of the gauge which it might be assumed would last. In order to reduce the cost, the weight per axle and the minimum distance between the axles, ought to be fixed, or in other words, the load ought to be distributed. The whole of the material, rails, sleepers, and other parts, would be of the same weight as for a narrow gauge. Mr. Ross.

Figs. 9.



The difference would then be found to be so small that no engineer who thought the matter out would recommend the narrow gauge for a new country with any prospects. It would be recollected that in 1896 a Light Railway Act was passed in England. No condition was laid down as to gauge, but in practice it had resolved itself into adopting the standard gauge of the country, with the weight of the permanent way and the rolling loads reduced. No doubt in a vast country there were cases in which a narrow gauge really became a

Mr. Ross. necessity, *e.g.*, isolated mountainous districts, mining settlements on high ground, and to and from such high lands and isolated docks; but those were exceptions, and as a general rule the normal gauge should not be broken. He put forward England as affording an example of a good normal gauge, but he hoped that in any new country the mistake would not be made of limiting the loading-gauge as had been done at home. The loading-gauge had been limited by structures such as tunnels and bridges, with the result that on the continent of Europe, and in America, where the same limits had not been imposed, it was possible to carry a much larger load than in England. He would not make any recommendations as to India, as he had never had the privilege of visiting the country; but it appeared to him to be a mistake to continue advancing narrow-gauge lines, except as connecting links between existing lines of narrow gauge. The standard gauge of 5 feet 6 inches was a magnificent gauge for the locomotive engineer, because he could easily build for it very powerful engines: it was also a gauge which enabled bulky loads to be carried in a compact manner. He would therefore encourage the development of the standard gauge of 5 feet 6 inches, and discourage the advancement of the metre gauge.

Mr. Wilde. Mr. S. J. Wilde remarked that the discussion seemed to him to have turned rather on the wrong point. The question at issue was not which was the better gauge—the broad or the narrow—but what was the best thing to be done in India under the present circumstances. One element had not been mentioned, either in the Paper or in the discussion. In addition to all the commercial questions, there was the Imperial question—the necessity of having plenty of rolling stock in the north in the event of war. In the north, south of Delhi, there was a large network of narrow-gauge lines; and he believed that in addition to the three schemes mentioned by the Author there was a fourth, namely, the conversion of the whole of the northern lines to the broad gauge, leaving the remainder as they were. It was very important to have the power to get rolling stock into that part of the country, owing to its being the most likely part to be the scene of war. The larger the quantity of rolling stock to draw from, the more would be available for war purposes without interfering with the ordinary traffic. The Bombay and Baroda railway was originally started to connect Bombay with Delhi on the standard gauge, and he believed the main reason why it had not been allowed to extend, although the capital had been raised, was the enormous cost of the original line from causes which had nothing to do with the gauge. For one thing, there were 10 miles of very large and important bridges over three great rivers; and again, the

Government of that day, in their wisdom, obliged the company to begin at Surat instead of at Bombay, and to work downwards from Surat to Bombay; and it had cost as much to carry the material from Bombay to Surat as from England to Bombay. Also the works were stopped during the Mutiny for some months, the result being a very heavy loss. Now a broad-gauge line was being made in continuation up to Delhi, which would be an advantage. His own view was that the narrow-gauge lines in the north should be converted to the broad gauge. Mr. Wilde.

Mr. C. W. HODSON remarked that the subject on which the opinion of the Institution had been asked for was one of very great importance to the development of railways in India, and he hoped the discussion would not be closed until a sufficient body of weighty opinion had been collected, which would be of assistance to the Author and his colleagues on the Indian Railway Board, and to the directors of the Indian railway-companies concerned, as a guide to them in coming to a wise conclusion with regard to the best policy to follow in the future. The facts and figures of the Paper might be accepted as fairly correct, although some of the deductions made required a little comment. With regard to the capacity of the two gauges, the Author's conclusion, that the capacity of the broad-gauge single line under Indian conditions was about double that of the metre gauge, was about what might be expected when it was remembered that the scale of loadings on the broad gauge was at present about 50 per cent. greater than that on the metre gauge, and the speed about 33 per cent. higher. It seemed probable, however, that as time went on that inequality might increase rather than decrease. The scale of loadings which was in vogue on the metre-gauge railways had increased much more rapidly than that on the broad-gauge, doubtless owing to the pressure of circumstances calling for the increase of capacity as much as possible. He had no doubt that a similar increase would follow in due course on the broad gauge; it was only a question of how soon the traffic would justify the expenditure. He thought that American experience showed that a very large increase of capacity was possible, and he supposed that as the traffic grew and required it, it would come; and it was possible that in the end the capacity of the broad-gauge single line would be more than double what the present scale of loadings allowed. It was very questionable whether the metre gauge would be able to increase in a similar proportion: if it did, he expected it would be at the expense of speed; and the consequence was that the ultimate limit of the capacities of the two lines would probably Mr. Hodson.

Mr. Hodson. not be in their present proportion, and the broad gauge would no doubt have a greater capacity than double the metre gauge —perhaps $2\frac{1}{2}$ to 1, or even more. With regard to the working-expenses, the Paper showed that the cost of working the passenger-traffic was, on the average, about equal on the two gauges, but that the cost of working the goods-traffic was about 25 per cent. more on the metre gauge. That was what might have been expected, considering the relative accommodation provided for passengers on the two gauges, and the low speed at which the metre gauge moved them in comparison with the other. In order to make a fair comparison it was necessary to consider what would happen if the two lines had equal accommodation and equal speed. If the metre-gauge lines were able to run as fast as the more important broad-gauge trunk lines did, or would have to do in the future, the increase of the metre-gauge working-expenses would probably be considerably more, and very likely the cost of running the passengers on the metre gauge would be at least 25 per cent. more than it was on the broad gauge.

It was a pity that the Author made no attempt to estimate the real difference between the capital cost of the two gauges. He arrived, indeed, at the figure of Rs.177,000 as the average cost per mile of the broad-gauge railways of his group, against Rs.71,000 per mile for the average of the metre-gauge lines of his group, a ratio of $2\frac{1}{2}$ to 1. But it had already been pointed out that the capacity, the equipment, and the efficiency for carrying heavy traffic, were altogether different, as were the alignments and the conditions under which the two gauges had been constructed. It was clear that it would be erroneous to conclude from the figures that the cost per mile of the broad-gauge group would have been really as much as two-and-a-half times that of the metre-gauge group, had they been constructed under anything like similar conditions. But the real reason for the great difference of cost appeared at once when the work done was compared. The Paper showed that the average yearly gross earnings of the broad-gauge group
374·5 was about Rs.20,693 per mile and that of the metre-gauge group was
56·6 Rs.8,349, which figures also were almost exactly in the ratio of $2\frac{1}{2}$ to 1. It had to be remembered, too, that the average cost of the broad-gauge group included a large expenditure on strategical lines which did not yet carry traffic anything like proportional to their cost. As had been said by many speakers on former occasions, and in the present discussion by Sir George Bruce, it was not the gauge that accounted for the difference of cost, but the traffic that had to be provided for. The cost of a railway, as a machine for carrying traffic profitably, depended far more upon its equipment than upon its gauge. Any saving that might

be obtained by having a narrow gauge was not real economy at all; it was only a sacrifice, more or less temporary, of capacity, and perhaps of efficiency; and it might have to be paid for much more dearly afterwards, as the necessity for increased capacity grew, either by extra capital expenditure or by increased working-expenses. He did not think the strongest advocates of the metre gauge could really claim more for it than that it could deal with a moderate traffic passably well, at a cost no greater than the broad gauge could do it: also, that it could enable more of the capital expenditure requisite to provide for a heavy traffic to be deferred until the development of traffic rendered such expenditure absolutely necessary; and that while the traffic was extremely light, it could work at a profit on which a broad-gauge railway of the ordinary type would starve. Where railways were made by private commercial enterprise, those attributes of the metre gauge were, of course, of great value to the shareholders, who depended upon their dividends for the security on which they could raise more money for the extension of feeder-lines, by which alone they could foster their traffic. But in India most of the metre-gauge railways had been built by the State, and he thought it would have paid the State better to have spent a little more capital, and thereby obtained a more efficient property. The State, with its unrivalled credit, could afford to look farther ahead and to build more for the future than a private company which depended on its dividends could possibly do. He therefore disagreed entirely with the Author's remarks that the difference in capital cost of the two gauges afforded ample justification for the early policy of adopting the smaller gauge. Both Mr. Waring and Mr. Burge had challenged the Author's estimate that, had that policy not been allowed, about 5,000 miles of the present railway-lines would probably not now be in existence. Mr. Burge had shown that this implied that such lines would cost £9,173 per mile for the broad gauge, against £5,133 on the metre gauge, a difference of about £4,000 or Rs.60,000 per mile; and he had naturally asked why India could not build branch lines cheaper than its main lines. The answer was, of course, that India could and did build lines for light traffic which cost much less than those for heavy traffic; in fact, which cost not much more than metre-gauge lines for the same traffic. But obviously, if those lines had subsequently developed a heavier traffic than was anticipated at the time of their original design, more expenditure would have been incurred upon them; and it would be the same with the metre-gauge lines. For that reason figures such as those selected by the Author from the Administration Report were

Mr. Hodson

Mr. Hodson. useless for comparing the initial cost of the two gauges. Not only were most of the smaller lines lumped in together with the larger ones, but also no distinction was drawn between the initial cost and the subsequent expenditure to meet the growth of traffic. It was necessary, therefore, to go elsewhere for further particulars, and fortunately that very useful branch of the Indian Railway Secretariat known as the Technical Section, which had collected and distributed such a large amount of valuable information—and which he was sorry to hear had recently been abolished—had from time to time published statements[1] showing the actual cost of a large number of lines of all descriptions, and of both gauges, which had been built during the last 30 years or so. On comparing those, it would be seen what great differences there were even between lines of the same gauge. Some lines had heavy bridging, others had little; some lines had been built when iron was cheap, others when it was dear; some lines were equipped with heavy permanent way and full ballast, others had hardly any ballast and second-hand rails; some had a full equipment of rolling stock, and others very little, or perhaps no rolling stock at all, because the line was to be worked by some neighbouring administration. Therefore in making a comparison it was better to exclude the bridges, permanent way, rolling stock, etc., and to compare the actuals for the other items of cost only, such as formation, stations, and so forth. He had therefore prepared the statement on pp. 54–5 on this principle, showing the cost of nearly all the railways for which he could get the figures, except the frontier railways and the lines of Assam and Burma, and others which had been built under abnormal conditions. The statement included figures for over 4,000 miles of broad gauge, and 6,000 miles of metre gauge. The general result was that the average original cost without rolling stock was: broad gauge, Rs.73,400 per mile, metre gauge, Rs.58,600; difference, Rs.14,800 per mile. In English money that was £4,900 for broad gauge, and £3,900 for metre gauge, or a difference of £1,000 per mile. That included everything except rolling stock; but if the major bridges and the ballast and permanent way were also excluded, the other items of the broad-gauge lines averaged Rs.28,700, and those of the metre-gauge Rs.29,000, per mile. That was to say, the two gauges, excluding rolling stock, bridging, and track, practically cost the same

[1] India. Office of the Director-General of Railways, Technical Section, No. 8, dated 23rd January, 1892. Statements showing Cost of Railways in India.

India. Office of the Director of Railway Construction, Technical Section, dated January, 1903. Statements showing Cost of Railways in India.

on an average taken on that large number of railways. These figures Mr. Hodson. included every line, and of course many of them were not branch lines at all; but the identity of cost of those "other items" ran all through the list. Practically, for nearly every metre-gauge line in which those items amounted to a given figure ranging between Rs.10,000 and Rs.40,000 per mile, it was possible to find a broad-gauge line built under fairly similar conditions at about the same cost. For example, excluding major bridging, track, and rolling stock, the metre-gauge line between Lucknow and Bareilly cost Rs.11,600 per mile, while the broad-gauge line between Wazirabad and Khanewal cost Rs.10,500, and the Rajpura-Patiala railway cost Rs.10,700. The metre-gauge Palanpur-Deesa line cost Rs.11,500, while the broad-gauge Peltad-Cambay, close by, cost Rs.11,200. The metre-gauge line between Rewari and Firozpur cost Rs.13,800, while the broad-gauge Sind-Sagar railway cost Rs.13,400; and so on. Among others there was the metre-gauge section of the Nizam's State railways, which cost Rs.34,200, whereas the broad-gauge section, built long before that, originally averaged only Rs.29,600 per mile. He thought this showed that, taking it generally, whatever difference there might be between the cost of lines of similar character on the two gauges, exclusive of bridging, track and rolling stock, that difference was too small to be distinguished in the accounts, or to be counted upon in actual practice, and therefore might justifiably be omitted altogether. It remained, therefore, to estimate the three excluded items. Bridges, of course, were mostly a matter of girders. The difference in cost between broad- and metre-gauge girders of similar type and of more than 60-foot span was between 15 and 25 per cent., and that of the masonry and foundations could not be more than 5 per cent. The average, therefore, on a complete bridge, would be 10 to 15 per cent.; and this meant that, on a line on which the metre-gauge bridges would cost Rs.10,000 per mile, broad-gauge bridges would cost not more than Rs.11,500 per mile. Track was simply a question of weight of rail and amount of ballast. Most of the metre-gauge lines had flat-footed rails and wooden sleepers, with about 8 cubic feet of ballast per lineal foot. If the weight of the rails remained the same, the extra cost of the larger and longer sleepers and extra ballast required for a similar broad-gauge road would be about Rs.7,000, or £467, per mile. If the rails were 62-lb. rails instead of 41-lb., or 75-lb. rails instead of 50-lb., the extra cost would be about Rs.5,000 more. That was to say, the total difference in cost between a broad-gauge and a metre-gauge track of similar character, differing only by about 20 lbs. of rail per yard, would be not more than Rs.12,000, or £800,

d. ORIGINAL COST PER MILE OF VARIOUS INDIAN RAILWAYS, BOTH BROAD AND METRE GAUGE,

Reference (a)	Broad-Gauge Lines.	Miles.	Original Cost per Mile (Thousand Rupees). Total.	Major Bridges.	Ballast and Permanent Way.	Rolling Stock and Ferries.	Other Items.
A. 23	Wazirabad-Sialkot (N.W.) . .	26	37·2	0·5	31·5	..	5·2
B. 30	Narwana-Kaithal (S.P.) . .	23	36·7	.. .	28·9	..	7·8
A. 28	Viramgam-Kharagora (B.B.& C.I.)	22	37·0	2·3	22·6	3·8	8·3
B. 26	Najibabad-Kotdwara (O. & R.).	16	23·6	2·5	11·7	..	9·4
		87					
C. 11, 12	Wazirabad-Khanewal (N.W.) .	201	41·2	1·3	24·4	5·0	10·5
A. 29	Rajpura-Patiala (N.W.). . .	16	30·7	..	20·0	..	10·7
C. 8, 9	Peltad-Cambay (B. B. & C. I.).	21	45·7	..	34·5	..	11·2
C. 3	Haidarabad-Shadipalli (Sind) .	59	31·5	1·6	16·5	0·6	12·8
A. 25	Sind-Sagar Railway (West Sect.)	329	56·4	7·9	30·3	4·8	13·4
C. 4	Sialkot-Jammu (N.W.). . .	25	49·6	4·1	30·1	..	15·4
B. 17	Ludhiana-Dhuri-Jakhal (ditto) (c)	80	49·6	1·1	33·0	..	15·5
A. 22	Khushalgarh Branch (N.W.) .	67	45·1	..	28·2	..	16·9
		885					
B. 22, 28	Ratlam-Nagda-Ujjain . . .	60	65·4	13·5	35·1	..	18·8
A. 6	Dhond-Manmad (G.I.P.) . .	146	67·1	13·2	34·8	0·1	18·9
B. 29	Delhi-Samasata (S.P.) . . .	402	53·6	0·8	33·2	..	19·6
		1,493					
C. 2	Anand-Peltad (B.B. & C.I.) .	14	55·5	..	32·5	..	23·0
B. 16, 17	Lucknow-Benares (O. & R.) .	187	58·4	2·9	32·5	1·9	23·6
B. 11	Ghaziabad-Moradabad (ditto) .	87	97·2	26·7	36·8	7·3	26·4
A. 3	Bengal Central	125	66·6	4·1	25·8	8·6	28·1
A. 7, 27, 34 B. 9	Four branches of the E.I. (b)	97	71·9	1·6	40·0	1·6	28·7
A. 2	Amritsar-Pathankot (N.W.) .	65	85·9	4·6	44·1	8·2	29·0
A. 1, 16	Amraoti & Khamgaon Branches.	13	70·4	..	40·0	1·5	29·0
B. 1	Amalner-Jalgaon (G.I.P.) . (c)	34	105·1	41·3	34·3	..	29·4
A. 17, 18	Nizam's State Ry. (B. G. Section)	334	74·6	6·3	33·3	5·4	29·6
B. 25	N.W.R. Rohri to Rahoki (Haidarabad)	178	75·4	4·4	31·3	9·2	30·5
B. 3	Bareilly to Moradabad (O. & R.)	56	134·3	53·8	45·0	3·4	32·1
		2,683					
A. 9–15, A. 30, B. 14	Indian Midland Ry. Bhopal to Agra and Cawnpore and Katni	790	98·4	24·0	39·4	0·1	34·9
A. 26	Multan-Kotri (I.V.S.) . . .	501	102·8	24·8	31·2	7·3	38·4
B. 31	Tapti Valley Railway (B.B.& C.I.)	155	77·4	9·1	29·0	..	39·3
B. 5	Chalisgaon-Dhulia (G.I.P.). (c)	35	97·2	21·2	34·4	..	41·5
B. 13	Hardwar-Dehra (O. & R.) . .	32	85·7	9·7	27·9	..	48·1
A. 4	Bhopal-Itarsi (I.M.). . . .	57	101·2	29·4	30·8	..	51·1
B. 12	Godhra-Ratlam (B.B. & C.I.) .	115	139·3	21·2	33·8	..	84·3
	Total mileage . .	4,368					
	Average of the first 12 items .	..	46·7	3·7	27·4	3·0	12·5
	Average of all except last 7 items	..	63·0	6·5	31·6	3·8	21·1
	Average of above broad-gauge lines	..	77·3	12·7	32·9	2·9	28·7
	Ditto without rolling-stock . .	..	73·4	12·7	32·9	..	28·7

(a) A refers to statements showing Cost of Railways in India issued as Technical Paper, No. 8, dated 28 Jan. 1892. B refers to statements issued in Secretary of Govt. of India P.W.D. No. 60 Rc., dated 20 Jan. 1903. C refers to statement issued in Director of Ry. Construction No. 70 Rc., dated 21 Jan. 1903.

(b) Namely, Patna-Gya, Dildarnagar-Ghazipur, Shoraphuli-Tarkassar, and Hathras Branch.

ARRANGED IN ORDER OF ACTUAL COST, EXCLUSIVE OF MAJOR BRIDGES, TRACK & ROLLING STOCK. Mr. son

Reference. (a)	Metre-Gauge Lines.	Miles.	Original Cost per Mile (Thousand Rupees). Total.	Major Bridges.	Ballast an Permanent Way.	Rolling Stock and Ferries.	Other Items.
A. 12, 13	Jodhpur to Marwar & Pachpadra	124	18·1	..	12·6	2·6	2·9
A. 19	Bhojapura-Kathgodam (R. & K.)	54	28·0	..	12·5	5·2	10·3
A. 1, 14 B. 31	Lucknow-Bareilly (R. & K.) .	204	35·6	1·6	15·6	6·3	11·6
B. 39	Palanpur-Deesa (R.M.) . . .	17	24·2	0·6	12·1	..	11·5
B. 16	Maimansingh-Jagannathganj (E.B.S.)	53	38·2	1·6	23·5	1·3	11·8
B. 6, 7, 9, 10	Four branches of B.N.W. . (e)	114	36·8	8·5	16·2	..	12·1
A. 18	Rewari-Firozpur (R.M.). . .	291	40·9	0·3	20·9	5·8	13·8
A. 17	Cawnpore-Achnera (R.M.) . .	253	43·5	4·8	17·6	6·6	14·5
B. 32	Muttra-Bindraban (R.M.) . .	8	31·6	..	15·3	..	16·3
B. 16	Brahmaputra-Sultanpur (E.B.S.)	59	46·9	5·4	24·7	..	16·8
		1,177					
A. 2	Bengal & North Western of 1888	376	63·5	10·6	20·2	12·2	20·5
A. 22, 23	Mysore State Railway (S.M.) .	296	48·0	3·1	16·5	7·8	20·9
		1,849					
A. 24	Semaria Ghat to Bettia, Pertabgunj & Sonpur (T.S.) . .	274	62·6	9·7	22·2	6·7	24·0
B. 8	Hajipur-Katihar Extension (do)(c)	161	65·1	19·5	21·4	..	24·2
B. 47	Mayavaram-Mutapet (S.I.) . .	54	47·2	8·5	13·4	..	25·3
A. 15	R.M.R. Delhi and Agra to Ahmadabad, Indore & Ujjain	1,030	70·7	11·4	22·8	10·7	25·9
B. 44 A. 51	S.I.R. Villupuram-Dhamarain and Nellore	387	63·6	1·0	17·7	9·8	27·1
A. 8	Katihar to Anchraghat, Dinajpur and Manihari (E.B.S.) . .	157	78·1	18·7	22·6	6·0	30·7
		3,912					
B. 23	Haidarabad-Godavari Valley (N.G.S.)	385	66·2	4·7	17·7	9·6	34·2
B. 19	Mogal Hat-Dhubri (E.B.) . (c)	39	152·6	85·5	21·5	8·0	37·6
B. 43	S.I.R. Madras to Tuticorin and branches . . . . . (f)	670	81·4	8·4	20·6	14·0	38·5
A. 10	Dacca-Maimansingh (E.B.). (d)	86	71·7	3·5	20·3	8·6	39·3
A. 9	Sara Ghat to Siliguri, Kauniya, and Dinajpur (E.B.S.) . (d)	231	85·2	7·8	23·8	11·4	42·2
A. 20, 21	S.M.R. Castle Rock to Poona, Hotgi, Harihar and Bezwada	1,012	84·8	12·1	20·8	7·8	43·6
A. 16	Indore to Khandwa (R.M.). .	86	145·7	38·5	26·2	13·3	67·7
	Total mileage . .	6,421					
	Average of the first 10 items .	..	36·9	2·6	16·9	4·5	12·1
	Average of all except last 7 items	..	56·6	8·4	19·7	7·6	20·9
	Average of all above metre-gauge lines.	..	67·2	9·5	20·1	8·6	29·0
	Ditto without rolling stock . .	..	58·6	9·5	20·1	..	

(c) Estimate taken, as actual cost not available. (d) Major bridging taken as half total bridging.
(e) Namely, Gonda-Tulsipur, Bhatni-Turtipur, Salimpur-Burhaj, and Nanpara-Katarnain Ghat.
(f) Of this, 167 miles were originally constructed on the 5-foot 6-inch gauge before 1868, and converted to metre gauge in 1878.

Hodson. per mile. In the cost of rolling stock there was practically no difference at all. It was well known that practically the same value of rolling stock was required to do a given amount of work, whether

STATEMENT COMPARING COST OF ROLLING STOCK OF VARIOUS INDIAN RAILWAYS WITH THE GROSS EARNINGS OF EACH IN 1903.

Name of Railway.	Length in Miles.	Gross Earnings in 1903.	Cost of Rolling Stock 1903.	Per Mile.		Ratio of Gross Earnings to Cost of Rolling Stock.
				Gross Earnings.	Rolling Stock.	
Broad Gauge—		Lacs.	Lacs.	Thousands.	Thousands.	1 to
East Indian . . .	2,231	724·38	1135·30	32·98	51·65	1·56
Eastern Bengal . .	278	102·32	157·31	36·78	56·45	1·54
Oudh and Rohilkhand	1,106	142·13	218·19	11·97	19·25	1·53
Great Indian Peninsula (and I.M.R.)	2,745	569·02	607·84	20·73	22·66	1·07
North Western . .	3,744	528·73	687·83	14·12	18·37	1·30
Bengal-Nagpur . .	1,667	155·19	334·43	8·73	19·88	2·15
Madras	1,400	173·47	271·10	12·40	19·31	1·57
Bombay, Baroda and Central India . .	825	183·76	215·95	23·85	25·93	1·20
Total (or average)	13,996	2,579·00	3,627·95	18·43	25·92	1·40
Metre Gauge—						
Bengal North-Western	1,418	111·09	192·58	8·38	14·29	1·73
South Indian . .	1,249	128·85	136·79	10·32	10·56	1·07
Burma	1,323	135·77	199·19	10·26	14·90	1·48
Eastern Bengal . .	732	79·10	115·80	10·33	16·63	1·46
Southern Marhatta .	1,646	95·58	148·89	5·81	9·04	1·55
Rajputana-Malwa .	1,871	233·74	235·14	11·88	12·49	1·05
Jodhpur-Bikaner .	824	27·44	39·00	3·33	4·73	1·42
Rohilkhand-Kumaun	280	18·16	39·25	6·48	13·49	2·15
Total (or average)	9,343	829·73	1,106·64	8·98	11·97	1·33

on the broad gauge or the metre gauge. The following Table, derived from the Administration Report of 1903, showed that the average cost of rolling stock per rupee of yearly gross earnings of the eight broad-gauge railways shown in the Author's Tables was 1·40 rupee, and that of the eight metre-gauge railways 1·33 rupee, a difference of only 5 per cent. Consequently the difference between the initial cost of the railways built under similar conditions on the broad and

metre gauges, could not exceed about Rs.1,500 for major bridges and Rs.12,000 for ballast and permanent way, making a total of Rs.13,500, or £900, per mile; and this might easily be reduced to Rs.6,000, or £400, per mile, if rails of the same weight were used in both gauges. Further, the Paper showed that even this difference disappeared as the traffic developed, and as additional capital had to be spent to improve the lines to deal with it; and that eventually the average cost of the older lines of both gauges turned out to be almost exactly proportional to the amount of traffic they carried. The conclusion therefore seemed irresistible that no real economy had been obtained by the adoption of the metre gauge, and that so far from the policy of 1871 having been justified by the facts, it had proved to be a very mistaken policy. That was, indeed, exactly what those whom Mr. Danvers in 1873 called the giants of the profession warned the Indian Government would be the case, and no doubt it was the case; but the advice of the engineers had been ignored, which was much to be regretted. Mr. Hod.

An old Indian friend, a strong advocate of metre-gauge extension, had asked him to explain exactly what he meant by light broad-gauge railways. His friend had said, "If you mean 40-lb. rails and taking heavy broad-gauge wagons with 12-ton axle-loads over them, I do not believe in it: and if you do not, why do you profess to be able to make light broad-gauge railways as cheaply as metre-gauge ones?" That was a very pertinent question, which raised the whole practical difficulty of making cheap broad-gauge railways. Of course no one professed to make light broad-gauge railways to do the same work that heavy ones would do, at the price at which metre-gauge lines were made. But why should such branches be expected to do this? In order to obtain cheapness some kind of efficiency must be sacrificed, and all that broad-gauge advocates contended was that it was not necessary to sacrifice efficiency so much or so permanently, in adhering to the parent gauge, as was the case with a narrower gauge. It was all a question of what the traffic was going to be. If it was going to be light and bulky, or in small consignments, there was little probability of having to take high-capacity wagons loaded to their full axle-loads. For passenger-traffic and for a great deal of goods-traffic the old-fashioned broad-gauge stock could be utilized, with axle-loads much less than the 12-ton axle-loads which his friend appeared to be afraid of. Care would have to be taken to use engines to match. If, however, it were found impossible to avoid using heavy modern wagons, the speed could be restricted, and, if the worst came to the worst, the loads might be reduced so as not to damage the rails; it was surely better to tranship a small portion of the traffic than the

lson. whole. He knew from experience that rails weighing 40 lbs. per yard would certainly carry a light broad-gauge traffic satisfactorily in broad-gauge wagons for a considerable time, even if there were some 12-ton axle-loads among them, provided the speeds were low. If a traffic too heavy for 40-lb. rails was expected, it was better to use 50-lb. rails. The extra cost of the additional 10 lbs. would be only about £150 per mile, and there would be a saving in renewals afterwards. He would even go to the expense of 60-lb. rails rather than change the gauge; it would be sure to effect a saving in the end. Better still, second-hand rails could be used if they could be obtained cheaply enough. The essential thing about a light railway, however, whether it was of broad or of narrow gauge, was that there should be no luxuries of any kind. The formation must be good and the permanent way sufficient for the traffic; but there must be no high platforms, or double ashpits, or architectural engine-sheds, or palatial staff-quarters or station-buildings; everything must be cheap, though it need not be nasty. He noticed that the Author attributed difficulty in making cheap lines to the severe conditions imposed on railways in India; but, as Mr. Waring had pointed out, those conditions were the result of the orders of Government, and could be relaxed if the Government chose. As a matter of fact, he did not think it had ever been intended that the rules referred to should act to prevent light railways from being made cheaply.[1] When in office he had done his best to make that perfectly clear to everybody.

The actual difference in capital cost between broad- and narrow-gauge railways was thus very small, and certainly not enough to justify the policy of adopting the metre gauge. If, then, that policy had failed to secure the expected saving, the question arose, had it

---

[1] The "Rules for the Opening of a Railway" now in force make this quite clear:—

"II. i. d.—In applying these Rules to the inspection of 'Light Railways,' it should be remembered that safety is entirely a relative matter, depending upon several factors, of which speed is the most important, and that in the case of lines of narrow gauge, or of lines intended for light traffic, it is for the Government Inspector to prescribe such limits of speed and other working conditions as will, in his judgment, secure the necessary safety. Similarly he should in such cases adopt a standard of convenience for the travelling public in accordance with the special conditions, rather than that of a fully-equipped trunk railway. . .

VII. i. 4.—But in exceptional cases, when a first-class standard is not required, as in the case of economically constructed lines worked at low speeds or with axle-loads considerably below the normal . . . the Inspector may recommend a departure from these Rules on conditions to be specified by him, provided the calculations forwarded with the Report show that the opening on such conditions will not be attended with danger to the public or the running staff."—C. W. H.

done harm? He thought the map (Fig. 1, Plate 2) showed that it had. Large tracts of country had been equipped with railways differing in gauge from neighbouring lines, whereas they might all have had the same gauge at little or no extra cost. As originally planned, the metre gauge was intended to be confined to certain areas where it was thought that the traffic would always be light. As long as the traffic of those areas had remained light, and as long as the metre gauge had been confined to those areas, the inconvenience had been comparatively small. That was probably what the Author meant when he said that, so far, India was not much hampered by the different gauges; in fact, he practically said so in another place where he remarked that hitherto the evil of the two gauges had not been so great as was anticipated. But as the cross-country traffic between different districts had developed, extensions on the metre gauge had been made into areas already occupied by the broad gauge, and considerable confusion had consequently arisen. Everybody knew about the troubles of transhipment, and Indian experience showed to how large an extent they could be reduced by good arrangements when the two railways were in the hands of the same administration. But when the transhipment took place between lines under different administrations, the troubles were more marked; and when it occurred between unfriendly or rival railways they became very serious. But worse than all the troubles of transhipment was the antagonism of interests which diversity of gauge engendered, and the duplication of arrangements and unnecessary expenditure which resulted from it. Neighbouring railways of the same gauge could help each other by interchange of facilities, but railways of different gauges could not; they could only fight. The manner in which the two gauges interlaced was particularly evident in the neighbourhood of Agra, Bareilly, Lucknow, and Cawnpore. At every place where the two systems touched complications arose; at every place where they crossed they became antagonistic. Two metre-gauge lines cut across the broad-gauge lines of that area, and others were proposed. One consisted of a duplicate line parallel to the existing broad-gauge line between Lucknow and Cawnpore, about 46 miles, costing about 25 lacs of rupees. That had been made on the plea of facilitating the interchange of rolling stock between the two metre-gauge systems in Rajputana, and in the United Provinces and Bengal. But as soon as it was made it began to be used as a competitive route, and traffic from Bareilly and Rohilkhand was diverted round by Lucknow, Cawnpore and Muttra, when it might have gone direct via Aligarh and Hathras, 350 miles shorter. Naturally rate-cutting and

Hodson. loss had ensued. The second metre-gauge link was now being made between Bareilly and Kasganj which would shorten this circuitous route and render the competition less wasteful to the metre-gauge systems; but the result was that the whole district from Delhi to Lucknow had become a debatable land where the two gauges had to fight each other for very existence at all points. Other proposals had been brought forward which would extend that debatable district as far as Allahabad and Benares. Who would have thought of making those cross lines if the Bengal and North Western on the one side, and the Rajputana on the other, had been of the same gauge as the two railways they crossed, the East Indian and the Oudh and Rohilkhand? The duplicate line between Lucknow and Cawnpore would not have been required at all, while the Bareilly-Hathras link would have been made by one or other of the two lines in whose territory it lay, and the other lines would, if necessary, have been given running-powers over it. All four lines would have benefited by it, whereas now it benefited two only, at the expense of the other two. Capital would have been saved, and reckless cutting of rates would have been avoided. He feared that that sort of interlacing would inevitably spread over other large areas in India unless steps were taken to check it, and a great waste of money would result. Sir Henry Kimber, speaking from the point of view of the metre-gauge South Indian railway, deliberately contemplated that as desirable; but Mr. Hodson would like to know what the Madras Railway authorities thought of the matter: there was another area in the neighbourhood of the Dindigal and Podanur districts where the results would be similar to those he had described in the north, if the confusion of gauges there were not checked.

He was not sure that he quite understood Sir Henry Kimber's remarks rightly, but they seemed to contain the suggestion that the simultaneous growth of the two gauges, which he advocated, would give the advantages of double track, and that in time of pressure the one system could be used for the up traffic and the other for the down. That would be quite possible, although somewhat difficult to arrange, if the two systems were on the same gauge. In the north of India duplicate lines had deliberately been made so that they might in times of pressure relieve and supplement each other: in fact, this was one of the advantages of uniformity of gauge. But diversity of gauge completely prevented anything of the sort. As lines of different gauges could not carry each other's stock, the stock of each must go back over its own line, and naturally each railway would desire to send it back full. In other words, both lines would compete for the traffic in both directions. Competition was all very well, and in some countries

where railways were owned by independent companies it might be the only way of keeping down rates and ensuring adequate facilities being given to the public; but the state of affairs in India was very different. There the Government owned the majority of the railways; and although it had leased some of them to companies, it had always remained the owner or principal partner, taking the greater part of the profits, and bearing the loss if there was any. Competition between such railways was practically competition between the different pockets of the Government purse, and wholly wasteful of the tax-payers' money: and it was quite unnecessary, for the State had reserved to itself powers quite sufficient to prevent unreasonable rates, undue preference, and other evils against which competition was elsewhere the only remedy. Moreover, the object of the State in owning the railways was to ensure their being worked for the good of the country, rather than for the benefit of individual administrations. Anything like reckless competition in rates tended rather to defeat or hinder that object, by absorbing revenue which could be better used elsewhere. Mr. Hod

The Author had certainly not overstated the objections to bringing the metre gauge into constricted areas like seaports, collieries, and other crowded centres of trade. Indeed, they might have been put much stronger without any fear of exaggeration. Mr. Hodson had been sorry to hear Sir Guilford Molesworth advocate bringing the metre gauge to Calcutta. The growth of the railway-accommodation in that city since Sir Guilford left India had been enormous, and the complications which the introduction of a second gauge in such places would bring about would be very serious. Not only would it be necessary to construct at least 150 miles of double metre-gauge railway or to convert one of the existing broad-gauge lines, and to provide a new terminus for the metre gauge at very heavy expense, but it would also be necessary to bring the new gauge into nearly all the wharves and jetties of the docks and river-face, and along the Port Trust railway; because it would be impossible to arrange that some berths should be served by one gauge and some by the other. If that were done by laying a third rail, it would mean not an increase but a decrease of capacity; for while a line or siding was occupied by a metre-gauge train it was closed to a broad-gauge one, which would carry half as much again. To make duplicate lines and establish transporters, as suggested in the Paper, would mean heavy expense and doubtful convenience. It would seem to be quite easy to give the metre-gauge system of the Bengal and North Western and Tirhut railways access to Calcutta on the broad gauge, if desired, when once the Ganges had

[Mr. Hodson.] been bridged, as he hoped it soon would be, in the neighbourhood of Sara. The line now being made from Katihar through Maldah towards the bridge should be of broad gauge, and the metre-gauge administration should work it and have running-powers over the existing lines of the Eastern Bengal railway into Calcutta, and be given facilities for its traffic at the existing termini in Calcutta and at the docks. The transhipment would thus be at Katihar, which was well adapted for it; and, being entirely in the hands of the metre-gauge administration, it could be done just as well as the Bombay and Baroda railway transhipment at Ahmedabad.

Again, there was the duplication of routes which the conflicting interests of the two gauges caused to be advocated. An example of this was the Haidarabad-Godavari railway from Manmad to Secunderabad, 386 miles long. It ran through the pick of the Nizam's Dominions, and had paid 3½ per cent. on its capital of £4,400 per mile within 4 years of its opening. He believed it could easily have been made on the broad gauge for an additional £1,000 per mile, and the expenditure would have been perfectly justified. That railway had been made on the metre gauge in a country completely surrounded by broad-gauge railways, and naturally the question of connecting it with the great metre-gauge systems north and south of it, had arisen. Even Mr. Waring, who was a thoroughgoing advocate of uniform gauge, had pointed out that the existence of these isolated systems necessitated some such link being made between Khandwa and Hotgi in order to facilitate exchange of rolling stock. The military authorities, he believed, were of the same opinion on strategical grounds. Who would advocate such a project if it were not for the diversity of the gauges? That link would be 400 miles long, it would cost at least £2,000,000, and much of it would pass through wild and rough country where it would have little prospect of developing paying traffic. The probability was that it could only live by trying to divert from the existing lines traffic with which they were perfectly capable of dealing. Feeder-lines were of course wanted in those districts as in all others, but they would be more useful if aligned as feeders to the existing lines, and not as chord lines simply short-circuiting lines which in that part of the country did not require it. The Author's map furnished another object-lesson. A new line of 2-foot 6-inch gauge had been made between Jabalpur and Gondia, and was to be extended southward towards Chanda in the heart of the mineral districts of the Central Provinces. The line crossed a strip of country where a north-to-south connection was badly wanted between the two main broad-gauge lines through Jabalpur and Nagpur respectively. Being of 2-foot 6-inch gauge, the line could

not supply that want, and the probability was that another line would have to be made across the same strip of country, probably through Itarsi and Nagpur, which would pass through a far more difficult country at far heavier cost. Thus an apparent economy might prove more costly in the end. On every hand was found the prospect of serious difficulties arising from the confusion of gauges, and, unless the spread of that confusion was checked, the result would surely some day become so serious as to be intolerable, and would have to be settled somehow. Mr. Hod

The question was: What should now be done? Whatever it was, it must be not only effectual but also commercially practicable. Twenty years ago some of the advisers of the Government of India foresaw this state of things, and in 1889 a number of the leading railway men of India were invited to express their views for the consideration of the Government. Most of them strongly advised definite action to check the growth of the evil. They recommended definite recognition of the 5-foot 6-inch gauge as the standard gauge of India, and the rigid prohibition of any extension of the metre gauge, except in areas where it was already established. They pointed out that all feeder-lines should be constructed on the same gauge as the parent line, but that anything of the nature of a link connecting with broad-gauge railways should be either constructed on the broad gauge, or so constructed that it could be easily converted to it. Unfortunately those recommendations had not been acted upon. They had been considered, but no definite policy had been decided upon; and the matter had been left so that each case as it came up should be considered on its supposed merits. The consequence had been that the broad- and metre-gauge advocates had fought over nearly every extension put forward since that time, and each decision had been based more upon the expediency of the moment than upon any definite policy. Had those recommendations been accepted in 1890, the growth of the confusion of gauges would have been checked, and the question to be dealt with at the present time would have been much simpler. It was not yet too late to adopt the recommendations, though they were now hardly sufficient of themselves. Not merely restrictive but remedial measures were now wanted, and he fully agreed with those speakers who urged that conversion was the proper course. He did not agree with some that things were now too advanced; indeed, he believed the longer conversion was delayed, the more imperative it would become. A great deal indeed could be done now. Of course, it could only be done gradually, and would require long preparation; but the thing to do was now to decide upon it definitely, and to begin at once to work steadily

Hodson. towards doing it. Other countries had had to sweep away diversity of gauge, and India would have to do the same sooner or later, and the longer it was delayed the more it would cost.

It was true, as Mr. Wilde had pointed out, that the question at issue was not which was the better gauge, broad or narrow, but what was the best thing to do under present circumstances; but it was useless to discuss the best course until it had been settled whether anything at all was necessary. He had endeavoured to show that something very definite was necessary if the present state of affairs was not to become intolerable, and now he would endeavour to show what the remedy should be. Doubling the metre gauge in India, exclusive of Burma and perhaps Assam and Bengal east of the Bramahputra, must, he thought, be put aside, as it would not be a remedy at all. Even if it were as cheap and as efficient in dealing with the traffic—which it would not be if the future were considered—it would not bring the object, uniformity of gauge, any nearer, but would rather encourage the growth of gauge-confusion, and perpetuate the inferior machine with its low speed and other disabilities to which Mr. Burge had referred in speaking of the South African railways. Moreover, it was doubtful whether simple doubling would provide for the growth of traffic very long. It would quadruple the present capacity of the metre gauge and raise it to double that of a single-track broad-gauge line of the present standard, that was, to about what it might be expected a single broad-gauge track would grow to in the future: but who could tell how long that would suffice? It might probably last for 20 years, but it certainly would not suffice for 50 years, and what was to be done then? A much heavier standard of metre-gauge loadings than the present would certainly be adopted long before then, and to introduce that after the doubling of the line would cost twice as much as doing it before. To convert metre gauge to broad gauge on even the present standard would double its capacity, and still greater increase could be provided by making the bridges a little stronger, so as to carry the broad-gauge loads of the future; and eventually, when the time came, the converted line could be doubled and made to carry eight to ten times as much as the present metre gauge. Considering the great growth of the traffic in India during the last 20 years, he did not think it was safe to limit the provision to what at most would be four or five times the present capacity.

Fortunately the present was a very favourable time for making a beginning in the direction of conversion. The traffic of India was increasing by leaps and bounds, and nearly all the railways were experiencing need of more powerful engines and larger wagons, and

of renewals with heavier rails and stronger girders. That was particularly the case on the more important metre-gauge trunk lines, several of which were proposing to introduce rolling stock practically as heavy as much of what had, up to a few years ago, been found sufficient for broad-gauge lines. Very considerable strengthening was therefore inevitable, and the question was up to what standard it should be done. If the standard selected was too low, there was the great danger that it would all have to be done over again before the structures were half worn out, and much waste would result. The difference in cost between girders 25 per cent. above present Government metre-gauge standard and full broad-gauge standard was comparatively small, probably not 10 per cent. It would be a thousand pities to adopt anything less than broad-gauge standard for the renewal of any large girders wherever strengthening of girders was being done on the metre gauge, whether early conversion was contemplated or not. The introduction of heavy rolling stock would necessitate renewals with heavy rails before long, but it was not necessary to look so far ahead with those as with girders, whose life ought to be so much longer. Consequently he thought it was clear that a heavy expenditure would be necessary in raising the standard, even if no conversion were made. The Author's estimate of the cost of conversion at about Rs.40,000 per mile included a number of operations which undoubtedly came under the head of strengthening, and which would have to be done in any case. If those items were eliminated, the cost due to change of gauge alone ought not to exceed more than £1,500 a mile, the rest being inevitable in the way of strengthening. If, therefore, conversion were undertaken in conjunction with a well-considered scheme of strengthening operations—which was certain to be called for in any case—the extra cost of the mere change of gauge would be much more moderate than if the conversion were deferred until afterwards. Sir Henry Kimber had effectively disposed of the alternative proposal for reducing the 5-foot 6-inch gauge to either the 4-foot 8½-inch or the metre gauge, but he had stopped short of similarly condemning the proposal to convert the metre gauge to the 5-foot 6-inch, and had admitted its advantages. With regard to the contemplated doubling of the first 15 miles of the South Indian railway from Madras to Pallavaram, Mr. Hodson knew that part of the railway well, and he fully recognized the need of relief for the suburban traffic; but it would be a thousand pities to cripple the development of that great property by not looking ahead and providing for the further developments which would follow. The

Mr. Hodson.

r. Hodson. whole line from Madras to Trichinopoli was very near the limit of its capacity, and conversion, or doubling, or duplication, would soon be a matter of importance. The line was paying more than 7 per cent. on its capital and could well afford to look ahead and adopt a far-seeing policy, even if at first it seemed a costly one. The proper thing to do, therefore, was to prepare for conversion between Madras and Villupuram at an early date, to be followed by the extension of the broad gauge thence to Trichinopoli, either by converting the existing line, or perhaps first by making the proposed chord-line on that gauge. After that, the reconversion of the old line to Erode to its original gauge would be an easy matter, and later on the broad gauge would be extended to Madura either by converting the existing line via Dindigal or by making another chord. Chords in that district would be no evil; the country was rich and only awaited development, and they would pay. Meanwhile, any doubling that might be necessary near Madras should have works fit for the broad gauge, and should not be laid to the metre-gauge except as a temporary expedient till the conversion southward became necessary.

The policy which he thought should be adopted for India was the following:—(1) Recognize the 5-foot 6-inch gauge as the standard gauge for all India, except Burma and Assam east of the Brahmaputra. (2) Recognize that the eventual conversion of all the principal metre-gauge lines in India proper was inevitable, and prepare the way for it whenever possible by making all new structures suitable for the eventual conversion. (3) Restrict the extension of the metre gauge rigidly to the districts already occupied by it. (4) Recognize that all branch lines should be laid to the gauge of the parent line, and insist that they should be so laid, or at least so that they should be easily convertible thereto. (5) Insist that all lines forming connections between broad- and narrow-gauge systems, or likely to develop into such connections, or into important branches of main trunk lines, should be constructed on the broad gauge, or at least be constructed so as to be easily convertible thereto. (6) Allow no extensions into constricted areas, such as seaports or collieries, already occupied by the standard gauge, except on that gauge. (7) Recognize that any metre-gauge line in India proper whose traffic was growing so as to demand the use of more than 10-ton axle-loads and 1 ton per lineal foot train-load was approaching the limit where conversion would become desirable, and that it must prepare to undertake conversion before further increase of loadings beyond that limit became necessary. (8) Such conversion when undertaken should commence at the point where the metre gauge debouched on the

broad gauge, and should proceed gradually by sections, pushing back the point of transhipment from time to time towards the less congested districts until these in their turn came up for conversion. (9) Recognize that conversion to standard gauge must precede doubling of metre-gauge railways in India proper. (10) Make a start on the Eastern Bengal railway as soon as the Ganges was bridged, and on the South Indian and on the Rajputana railways as soon as the traffic justified it. Those views he had laid before the Government of India 2 years ago, but of course nothing could be done until the new Indian Railway Board was established and in working order. He believed that this policy was a perfectly practicable and a constructive policy, and that in the end it would prove economical and effectual. He trusted the Institution would recognize its soundness and support such a policy with no uncertain voice. Perhaps some of the directors of the companies concerned might fear that it might curtail their dividends for a time, but he felt sure that it would prove remunerative in the end, and that it was the proper thing for India generally. Mr. Hodso

Mr. ALEXANDER IZAT pointed out that the gauge question had existed ever since railways were begun in India. At that time it was still undecided in England whether the 7-foot or the 4-foot 8½-inch gauge was the better, and the Indian Government seemed to have thought that the wise thing to do was to take a middle course and adopt a gauge of 5 feet 6 inches. This was the only gauge for about 15 or 16 years, during which about 5,000 miles of railway were constructed. From various causes the cost of these railways was heavy, being about £18,000 per mile, and at the opening of one of the sections between Delhi and Lahore about 1868, the Viceroy, Lord Lawrence, remarked that the heavy cost of the railways prevented the Government of India from undertaking their construction to the extent the country required; but that if the cost could be reduced by one-half, or even to about £10,000 per mile, the Government could afford to cover India with railways. The question of cheap railways was thereafter much discussed, with the result that, about 1869 or 1870, the metre gauge with 41¼-lb. rails was decided upon, and since then had been adopted in different parts of the country. The chief object of its adoption had been to open up the country with cheap railways. The old standards of railway requirements were abandoned, and new ones were adopted, with the result that, since 1870, 11,421 miles of metre-gauge railways had been constructed, at an average cost of £4,700 per mile. Those lines had not only provided cheap and easy communication in large tracts of Mr. Izat.

Mr. Izat. the country, to the great benefit of the public and the Government, but had also proved financially successful, and were earning an average dividend of 6 per cent. on the capital expended on them. They had further added greatly to the traffic-earnings of the standard-gauge lines, and thus had helped considerably to place these in the satisfactory financial position which they had only lately attained. The introduction of the metre gauge had thus been fully justified in every way. In the same period, since 1870, about 9,000 miles of ordinary standard-gauge line had been built at an average cost of probably not more than £8,000 per mile, the Oudh and Rohilkhand railway having cost £7,800, and the Bengal-Nagpur railway £8,900 per mile. In regard to these lines also the requirements of India, as expressed by Lord Lawrence, appeared to have been met. Some of the speakers had argued that, instead of the metre gauge, a light standard-gauge line should have been adopted, and inferred that the latter would have avoided the inconvenience of a break of gauge, and would have cost little more than the former. That view was erroneous. The adoption of a light standard-gauge line would practically be a break of gauge, and would necessitate the provision of special light rolling stock for its use, as ordinary standard-gauge stock could not be used on it. All traffic would therefore have to be transhipped at junctions between the light and the ordinary standard-gauge lines. The axle-loads permitted under the Government regulations were 7 tons for carriages and wagons and 8 tons for engines, for the 41½-lb. rails in use on the metre gauge, which, in order to maintain similar conditions, a light standard-gauge line would have to adopt; whereas for the ordinary standard gauge the axle-loads were 12 tons for carriages and wagons, and 17 tons for engines. The ordinary standard-gauge wagons, then, could only run on the light standard-gauge lines by carrying loads 50 per cent. less than metre-gauge stock easily bore, and ordinary standard-gauge engines could not run at all. To avoid the inconvenience of what would be practically a break of gauge, all the standard-gauge branches would have to be equipped with girders, ballast, rails, sleepers, and stock sufficient to carry the ordinary standard-gauge axle-loads—the practice that had been followed in India. The difference in cost between similarly-equipped standard- and metre-gauge lines need not exceed £1,000 per mile in open country, but in rough or hilly country the difference would be much greater, because, with the sharper curves that could be used on the metre gauge, a considerable saving in the earthwork and bridging ought to be possible. As to the cost of an ordinary standard-gauge line and a metre-gauge line,

practical examples were more reliable than any estimates, and he therefore took the Oudh and Rohilkhand railway as an example of the standard-gauge, and the Bengal and North Western railway as an example of the metre-gauge lines. Both those railways, with which he was fully acquainted, had been well and economically constructed under modern conditions, and were fully equipped with workshops and terminal stations, which, though very costly, were frequently overlooked in making comparisons between short branches,. They ran through similar country, the only difference between them being that the Oudh and Rohilkhand railway served many more large towns and important markets than the Bengal and North Western. The former had cost £7,800 per mile, and, while earning £800 per mile per annum, was now returning 5·3 per cent. on its capital cost; but it was evident that the returns in early days were very small, as in the Government accounts there was an outstanding balance of uncovered interest amounting to about £2,000,000. If this large sum were included in the capital cost, the return at present would be 4·2 per cent. instead of 5·3 per cent. The Bengal and North Western railway had cost £5,300 per mile, and whilst earning £559 per annum, was returning 6·3 per cent. on its capital cost, and—what was of great importance—there had never been any outstanding balance of uncovered interest. Had the Bengal and North Western railway been constructed on the standard gauge at a cost of say £7,800 per mile, its present earnings would not have yielded more than 3½ per cent. on its capital cost, and for the last 21 years it had been open for traffic, during which time its earnings had been much less than they were now, the company would have been in a very poor financial condition. However, constructed as its lines had been on the metre gauge, the company had not only been able to pay fair dividends since its incorporation, but latterly good dividends. It had attained a good financial position, and had been able at its own risk to raise money and develop its system with the network of lines that now existed north of the Ganges. The company was a purely private enterprise, had had no guarantee from Government, and had received no direct assistance from Government except free land, the full value of which had been more than repaid by services rendered; and it had not cost the Government a penny. The company's success and its increased usefulness to the country had been solely due to its having been constructed at a low cost as a metre-gauge line. The other metre-gauge lines, almost without exception, had also been financially successful throughout their existence; and experience had shown that lines of this gauge could

Mr. Izat. be constructed and worked profitably where a standard-gauge line would starve. On the other hand, the standard-gauge lines, although they were the oldest, and had been working for more than half a century, had only in recent years, when fed by the metre-gauge branches, returned a fair dividend on their capital cost. How important that feeding-process was would be made clear by stating that upwards of 400,000 tons annually were transferred to the East Indian railway by the Bengal and North Western railway at Mokameh for Calcutta, giving a lead of 284 miles. The standard-gauge lines had been a heavy financial burden on the State, notwithstanding the fact that they served the richest and most populous parts of the country, and the chief trade-centres and seaports. If the great loss in interest on capital incurred on them were added to their capital cost, the latter would be very much higher than it was shown to be, and in the case of the Oudh and Rohilkhand railway the capital cost would be increased by 25 per cent. India, though a large country, was in some respects a poor one, and, as in 1870, it still required many thousand miles of railways; but to have them at all it must have them made cheaply. It would seem, therefore, that the proper course to pursue was to continue the policy adopted with such success in 1870, of whose results the Government of India and their agents might well be proud, and to treat each case as it arose on its own merits: to adopt the standard gauge for new lines where the nature of the traffic, special circumstances, or military or other requirements justified its cost, and the metre gauge where it would meet all the necessities of the case. Each gauge should also be allowed to develop inside its own district, and the metre gauge should have access to the large towns and the seaports, and be permitted to make itself as useful to the country as possible. The estimate given by the Author for doubling a metre-gauge line was too high; it might safely be put at £2,000 per mile, and a short section of 9½ miles of the Bengal and North Western railway had actually been doubled for £1,700 per mile, or about half the cost of changing a metre-gauge line to the standard gauge. The change to the standard gauge might double the carrying-capacity of the railway, but to double the metre-gauge line would increase its carrying-capacity four or five times at least, even under existing working-conditions. Moreover, conversion must be carried out from one end, whereas doubling could be done wherever and whenever required. Again, conversion would spread the transfer from gauge to gauge over numerous junctions where branches came in, and it was an established fact that transfers could be made easily at places where large quantities

were dealt with, and proper superintendence could be provided, but were difficult at minor junctions. Doubling would therefore give by far the best results, would meet the requirements of the country for many years to come, and should therefore be adopted. The break of gauge was an inconvenience, but it was an infinitesimal inconvenience compared with that of having no railway-communication at all. India urgently required many thousand miles of railway, and the policy that would give her the largest number of miles in the least possible time without burdening her finances was that which would best meet her urgent wants. The question was really a financial one, and if the needs of the people could be reasonably met whilst giving fair returns on the capital invested, ample money would be forthcoming for the great extension of railways still required; but if the railways made were not financially successful, money would be difficult to obtain, and progress would be very slow. Mr. Izat.

Mr. OLIVER BURY fully appreciated the difficulties of the situation in India. Although he had no personal knowledge of that great country he had had some experience of similar difficulties in South America. The Author remarked that it was difficult to resist reasonable demands of metre-gauge lines when they desired to find an outlet to ports, or to get to the coast; and precisely the same thing had been found in the Republic of the Argentine, the railways of which were shown in *Fig. 10*. Of the 5-foot 6-inch gauge there were 7,572 miles at the end of 1904, and of the metre gauge about 3,370 miles. The 4-foot 8½-inch lines he would not refer to, as they were bordered by the rivers Parana and Uruguay, which he thought were not likely to be bridged for some time. With a view to obtain some idea of the comparative cost of the broad gauge and the metre gauge, he had taken out particulars of the capital of the Argentine lines; and he found that whereas the average capital per mile for the metre-gauge lines was £9,675, that for the 5-foot 6-inch lines was £10,161—hardly any difference. Anyone who knew the country would realize that the best value was in the 5-foot 6-inch gauge. The narrow metre-gauge lines had had to get down to the port of Santa Fé, where large ships were loaded for Europe, and to Rosario where also deep-draught ships were loaded, and now they were creeping down to Buenos Aires, and would soon be there. In fact, there was danger that the difficulty in the Argentine would shortly be the same as that in India; and he thought it would be wise to confine the narrow-gauge lines to the hilly districts and the north-western part of the Republic. Turning to another part of the world, namely, Egypt, a Commission was formed in December, 1904, to report on the Egyptian railways, of Mr. Bury.

Mr. Bury. which he was appointed the engineering member. One of th points of reference was as to the advisability of broadening th

Fig. 10.

RAILWAYS OF THE ARGENTINE REPUBLIC.

gauge between Luxor and Assuan (*Fig. 11*). Apart from the Delt railways, which were of 2-foot 6-inch gauge, there were in Egypt abou 1,500 miles of 4-foot 8½-inch gauge, and between Luxor and Assua

the gauge was 3 feet 6 inches. Before the Commissioners went out to Egypt they thought it seemed advisable to widen that line; but after much consideration of the matter on the spot, they had come to the opposite conclusion. In the first place, there was practically no Mr. Bury.

Fig. 11.

EGYPTIAN RAILWAYS.

traffic on the line, there being but one train each way daily for passengers and one goods-train; the goods, such as they were, then going up to the Sudan. The permanent way was very light, while the sleepers were too short for the 4-foot 8½-inch gauge, and there seemed to be no possibility of finding a market for them. There was a certain amount

Mr. Bury. of tourist-traffic for 2 or 3 months in the year to and from Assuan, and the tourists had to change trains; this was no doubt an inconvenience about which the Government officials heard a good deal. The Commissioners were asked to have due regard to the commercial side of the question, and they found that to broaden that line of about 213 kilometres would cost a good deal more than £500,000. The Commission had come to the conclusion that inasmuch as there was a network of 3-foot 6-inch gauge in the Sudan, it would be just as convenient to keep the break of gauge at Luxor as to transfer it to Assuan, because sooner or later the lines would be connected with the 3-foot 6-inch gauge of the Sudan, and probably with the rest of Africa. They had therefore had no hesitation in recommending the Government not to widen the gauge at present, but to put the rest of their railway system into good working-order. Not much had been heard in the discussion from the traffic point of view. He had had the somewhat unique experience of having managed a metre-gauge line, a 4-foot 8½-inch line, and a trunk 5-foot 6-inch line in South America. His own experience, and he thought that of many others, was that the 5-foot 6-inch gauge was the best, and if he could not get that he would wish for the 4-foot 8½-inch. He did not wish to disparage the metre gauge, because an enormous tonnage could be carried on it. Probably not every member of the Institution was aware that in the Argentine there were running on metre-gauge railways sleeping-cars fitted with transverse sleeping-berths, and dining-cars with precisely the same arrangement of seats and lavatories as in England. The Author put the relative capacity of double and single lines at 5 to 1, but Mr. Bury thought that was too low. As a rule, in practice a double line could carry more than five times as much as a single line; at least, that had been his experience abroad, and it certainly was so on the Great Northern railway, where it was found that a single line could not do anything like one-fifth of what a double line could do. It might be interesting to state what could be put on one pair of metals. He found that on the High Barnet branch, in regular everyday work, seventeen trains per hour ran on one pair of metals. With regard to the solution of the problem under discussion, he thought the suggestion that the gauges of India should all be changed to 4 feet 8½ inches could be put aside as involving a useless waste of money. To convert the 5-foot 6-inch into a metre gauge would surely be a distinct step backwards, and equally out of the question. The third suggestion—that the metre-gauge lines should be broadened to 5-feet 6 inches—was attractive if it could be done; but after what Sir Henry Kimber had said it would seem to be financially impossible to broaden all

b.12

the metre-gauge lines to 5 feet 6 inches. Mr. Bury put forward any suggestions with regard to India with the greatest diffidence, as he had never been there; but he agreed with Mr. Ross that the broad gauge should be encouraged and the narrow gauge confined as far as possible to certain areas. Each case must be treated more or less on its merits, and the two examples he had given illustrated that view. Mr. Bury

Mr. R. PRICE-WILLIAMS remarked that, having taken part in the discussion of 1873, having in the interval visited India, and having in recent years been called upon by the Railway Commissioners of two of the Australian colonies to investigate the subject of the cost of unification of gauge, he was glad to have the opportunity of alluding briefly to this important matter. When in 1873 the subject was brought forward by Mr. Thornton, he believed it was done in a tentative way, as at that time not a single mile of metre-gauge line had been laid. The discussion was therefore of an academical character, chiefly turning on Sir John Hawkshaw's, Sir John Fowler's, and Sir George Bruce's estimates of the saving in the cost of construction, as there was no opportunity then of forming any judgment with regard to the actual working of narrow-gauge lines. In the interval 33 years' experience had been gained, and, more important still, as bearing directly on the question, there were, in the Administration Reports, records which furnished complete means of ascertaining how the metre-gauge lines had worked as compared with the standard-gauge lines. Although the Author said the question was not to be settled by figures, it was quite evident that the economical aspect of the question was really very important, and Mr. Price-Williams was surprised that neither the Author nor previous speakers had fastened on what was really one of the cardinal features of it, namely, the enormous development of traffic that had taken place. Plate 3 and the accompanying Table (both prepared from information furnished in the Administration Reports) showed the development of Indian railway-traffic during the last 33 years; both the tonnage of goods and the number of passengers carried had increased more than tenfold during that period, as compared with only a fivefold increase in the mileage of railway open. India was not only a large country; it had a population enormously larger than any other portion of the British Dominions. He knew of no other instance of railways having to cope with the growth of traffic arising from such an immense population and such marvellous resources. The area of Australia was certainly larger, but its population per square mile was about Mr. Price Williams.

Mr. Price-Williams.

Year or Period.	Goods Tonnage Gross 1 = 1,000.	Total in Period 1=1,000.	Average Rate of Increase per Annum Per Cent.	Passengers 1 = 1,000.	Total in Period 1 = 1,000.	Average Rate of Increase per Annum Per Cent.
1871 . . .	3,542	..	..	19,283	..	..
(1871–80) . .	..	65,320	..	..	314,541	..
1881 . . .	13,214	..	..	54,764	..	..
(1881–90) . .	..	187,661	11·13	..	845,155	10·39
1891 . . .	26,159	..	..	122,855	..	..
(1891–1900) .	..	332,296	5·88	..	1,494,258	5·79
1901 . . .	43,392	..	..	194,749	..	..
(1901–1903) .	..	136,613	4·83	..	601,628	3·90
1903 . . .	47,684	..	..	210,231	..	..
Annual average (1871–1903) .	..	..	8·48	..	..	8·07

1·25 as compared with 166 in India and 55 in Great Britain. The Author drew attention to the very significant fact that for some of the metre-gauge lines the limit of the carrying-capacity had been reached, and his statement practically amounted to an admission that there was no alternative but either to double the existing metre-gauge lines, or to convert the metre-gauge lines into a single standard track. The problem was a very important one, and, having an open mind upon the subject, the Author very properly submitted it to the consideration of the Institution which had already had it under discussion on two occasions. Owing to the growth of traffic, the light railways had now fulfilled their object as pioneer lines, and as feeders for the standard-gauge lines, for which they were originally intended; in fact, they ceased to be light lines in 1873, and had now become competitive with the Government lines, notwithstanding the Author's statement that both narrow-gauge and standard-gauge lines were really the property of the Imperial Government. If the past rate of increase of the goods- and passenger-traffic, or anything like it, continued during the next 30 years, he would say deliberately that it would not only necessitate the doubling of the metre lines, but also the doubling of the standard lines. Possibly if the traffic did not continue to grow so rapidly, the requirements of the next 30 years might, as the Author thought, be provided for by doubling the metre-gauge lines, but Mr. Price-Williams much questioned it. He had carefully examined the reports, and he saw nothing to indicate any slackening in the development; and, from

what he had seen in India, he thought the rate of development must continue undiminished. The break of gauge alone, the cost of which the Author said was 5½d. per ton, would necessarily be in any poor country a great hindrance to the development of traffic. It was stated in the Paper that the question of the Imperial Government's financial interest did not enter into the scope of this question; but the Government owned the lines, and was now subjected to competitive traffic. Was the Imperial Government, which had invested 247 millions sterling in the railways, to have no voice in the matter? His own opinion was that matters had come to a crisis, and some practical means should be devised for terminating the present highly unsatisfactory and anomalous condition of the Indian railways. Vested interests had every right to be considered, but Imperial interests ranked first. The estimates made of the cost of unification on the standard gauge amounted to about 29 millions sterling. The estimate for doubling the metre gauge was one-third more. The matter had come before the Institution not for individual opinions but for a definite pronouncement; and he thought that in view of the difficulties, annoyances, and hindrances to traffic which the present position involved, it should be said that the time had arrived when the matter must be definitely settled one way or another. The word "impossible" was regarded very sceptically by members of the Institution. It had been their privilege to perform the "impossible" on more than one occasion. A striking instance of that had occurred within the last 2 years, involving the vested interests of eight very large companies supplying a population of 7,000,000 with one of the necessaries of life. The matter had been settled by an Act of Parliament, appointing an eminent judge, an eminent Past-President of the Institution, and a great financial authority, as arbitrators; and with their assistance all vested interests had been reconciled, and he thought both parties were perfectly satisfied. The "impossibility" in connection with the Indian gauges might perhaps be settled in somewhat the same way, and it must be speedily settled if India was to have the requisite means for the proper development of its resources. A pronouncement by the Institution to that effect should lead to a solution of the problem. Mr. Price-Williams.

Mr. WOODFORD PILKINGTON observed that his interest in the break of gauge in India dated back to 1873, when the late Duke of Argyll was Secretary of State for India. He represented a company who were dealing with an invention for transferring rolling stock, and the Duke of Argyll, on the advice of General Strachey, consented to purchase the patent for £100,000. The invention was one that Mr. Pilki

'ilkington. shunted traffic between any gauges within reasonable limits, and would have saved the millions that would be spent in altering the gauges of India. Unfortunately the Ministry at that time broke down, and when the new Ministry came into power, Lord Salisbury, who was the new Secretary of State for India, declined to complete the purchase, the reason given being that the Government was interested only in the main line between Bombay and Calcutta, which they had resolved to make of uniform gauge throughout at any cost.

Mr. Jebb. Mr. G. R. JEBB thought it was a sound principle to go upon that when any extension of a narrow-gauge line was decided upon, the earthworks and bridges of that extension should be made sufficient for a standard-gauge line, if there was any probability of future extension making a connection with a standard-gauge system possible. At first the narrow-gauge line would be made to the end of the first extension, and then be converted when necessary.

r. Whyatt. Mr. H. GILBERT WHYATT considered that the question of conversion should be postponed for the present, and the metre-gauge lines should be doubled. In course of time the traffic would be so heavy that four lines of rails would be required, and then would be the time to convert the double line of metre gauge into the double line of standard gauge. It would be far better to do it then, and it would be cheaper to convert a double line to standard gauge than to construct two additional lines or to quadruple the metre gauge. He thought that certainly the present was the wrong time to do it. New metre-gauge lines should be prohibited absolutely, except under very special circumstances, especially such lines as that between Haidarabad and Manmad; a metre-gauge line should be prohibited in a district where no other metre-gauge line had been constructed, such as the line from Guntakal to Bezwada; and metre-gauge lines should be kept out of Calcutta. But even where new metre-gauge lines were permitted, all the bridges should be made strong enough and wide enough for broad-gauge lines, and all stations should be made wide enough between the platforms to allow of conversion afterwards without incurring extra expense, that was, the centre-lines in stations should be set 15 feet 6 inches apart, instead of 14 feet 6 inches. Outside the station sufficient land should be taken, and all fixed works should be constructed to allow of the full width of 28 feet overall. Also, as had been pointed out, the earthworks should be constructed sufficiently wide. To sum up, he thought that the metre-gauge lines should now be doubled, but should be confined to their own districts; and when the next extension was required, they should

be converted to double lines of standard gauge, instead of quadruple lines of metre gauge. Mr. Whya

Captain G. R. HEARN, R.E., observed that, whilst the matter was being discussed from engineering and commercial points of view, it might be interesting to hear the opinion of the natives on the gauge question. He happened on one occasion to be talking to a priest in Muttra with regard to the Agra-Delhi chord railway, which he recently helped to construct. The priest said he was glad the railway was coming, because it would mean more traffic; and he hoped broad-gauge lines would soon be constructed through Rajputana. When Captain Hearn inquired why he expressed that hope, and pointed out that there was already efficient means of getting into Bombay by the Rajputana-Malwa line, the priest replied that that was a "small line, a wretched line," and that by it 2½ days were required to get to Bombay. Although it was said that the natives of India did not care about speed, he thought they did appreciate it; and he believed that the metre-gauge line would not permit of the speed likely to be required, because it was not possible to run at 60 miles per hour over a metre-gauge line. Capt. Hea

Mr. G. H. LIST considered that any question of now reverting in India to the 4-foot 8½-inch gauge was quite beyond the stage of practical politics. Work on both standard and metre gauge had gone too far for this to be possible, though 30 years ago it might have been done at reasonable cost. The good steady English habit of compromise would, he thought, be safest in this case also. In fact, the adoption of the 5-foot 6-inch gauge originally was a compromise, being a splitting of the difference between the 4-foot 8½-inch and 6-foot gauges.[1] But it seemed as if the originators of the 5-foot 6-inch gauge had not had the courage of their own opinions, or the foresight to see the potentialities of their own act. Having adopted a wider gauge, they proceeded to construct the earlier lines on English standards, making tracks 12 feet between centres and building high-level, narrow, double platforms at all stations. Every station between Calcutta and Delhi, except engine-changing stations, was built thus. It was this fact that handicapped standard-gauge rolling stock, and prevented it from showing as high a ratio of capacity to gauge as the metre-gauge stock. The late Colonel Conway-Gordon, manager of the North Western railway, made wagons 11 feet wide, but they were barred on the East Indian Railway. India was too poor to have money to spare for such a task as changing all lines to 4 feet 8½ inches; she required all her money for new lines. But Mr. List.

[1] See H. Bell, "Railway Policy in India," chap. iv. London, 1894.

Mr. List. the older standard-gauge lines should be systematically taken in hand, and their original faults corrected. As regarded admitting metre-gauge lines to the seaports, he had no knowledge of Calcutta, Bombay, or Madras, but he knew Karachi intimately. At one time he had held the opinion that it would be good policy to allow the metre-gauge, now 110 miles away, to enter that port, provided it could be kept to its own wharves or jetties; but on further consideration he had feared that this would not be possible, and a mixed gauge on the Karachi jetties as he knew them would prove an intolerable nuisance. Besides, there was no real necessity to take the metre-gauge to the jetties, as very little of the produce from up-country went direct to the ship's side, and nearly all imports went to an import-yard from the ship. Most of the wheat coming from up-country was unloaded and stacked in store-houses at the jetties or at merchants' warehouses, as it arrived much faster than ships could take it. The railway had a working agreement with the merchants to handle all grain, etc., and put it alongside ships at any time, at a rate of 1 pie per maund ($2\frac{1}{4}d.$ per ton). There was thus no real necessity for the metre gauge to go alongside the ships, as its wheat-traffic could be dealt with easily and as cheaply as under existing conditions. The construction of a new standard-gauge line between Nagda and Muttra, now in progress, would very materially affect the through grain-traffic now passing over the Rajputana-Malwa metre-gauge line to Bombay from the country of which Delhi was the centre. This would postpone for some years the necessity of doubling that line or changing its gauge. But if its capacity must be increased, he was rather inclined to regard with favour a modification of Sir George Bruce's suggestion, and would lay a new broad-gauge line parallel to the present line by a new route, and so keep the metre-gauge connecting link between the North Ganges metre-gauge system and the other Rajputana and Kathiawar metre-gauge systems, which were sufficient for the needs of the native states they belonged to. It was, he thought, certain that as long as the metre-gauge systems existed in Kathiawar, Gujrat, and other native states in Rajputana, and connections were made to the southern system, the metre-gauge systems north and east of the Ganges would claim the maintenance intact of the present connecting link, or compensation for its abolition. But in connection with this question of the gauges he recommended perusal of the book published by the late Mr. Horace Bell, M. Inst. C.E., in 1894, on "Railway Policy in India," more especially chap. iv. It would be seen that the pessimistic views as to the success of the standard gauge had been at that date completely falsified. Mr. List

would suggest as a compromise :—(1) The retention of the metre-gauge Mr. List. for (*a*) all lines south of latitude 16° except existing broad-gauge lines; (*b*) all Rajputana, Kathiawar and Gujrat; (*c*) all north and east of the Ganges. (2) The conversion of the Godavari Valley and Guntakal-Bezwada lines to standard gauge. (3) The connection of the metre-gauge north and south systems between Khandwa and Hotgi. (4) The connection of Bombay and Karachi by a standard-gauge line to Badin, or the crossing of the Indus again lower down at Tatta. He believed that projects (3) and (4) were actually under consideration and survey. The 2-foot 6-inch and 2-foot gauges should be allowed only as pioneer lines, or as distinctly hill-district lines where the country was exceptionally difficult, or traffic never likely to be heavy. The lines of 2-foot 6-inch gauge made on the north-west frontier for military purposes were now being converted to standard gauge. Another 2-foot 6-inch line just sanctioned, from Saharanpur to near Delhi, should be made to the standard gauge; it would traverse a very rich, densely populated, and well-irrigated country. It was, however, to be made suitable for easy conversion to the standard gauge. The lines of 2-foot 6-inch gauge proposed in Central India would, no doubt, also be converted to standard gauge in a short time, as the country became opened up and traffic developed. All future construction in the plains and easy country should be of standard gauge, or of 2-foot 6-inch gauge built for conversion thereto. No more metre-gauge trunk lines should be built; only branch extensions strictly within the territories now occupied by metre-gauge lines. He did not advocate light standard-gauge lines—that was, lines with a light permanent way of 40-lb. to 50-lb. rails—because a very light permanent way would not take main-line loads except at such low speeds as to block traffic. If there was reasonable traffic to start with, a standard-gauge road should be made with 60-lb. rails, money being saved on stations and buildings at first. If traffic was to be fostered, a 2-foot 6-inch gauge line should be made with formation to take the standard gauge in due time. The North-Western railway had made 100 miles of what was virtually a light standard-gauge line. It was almost a surface line, with paved dips or Irish bridges at waterways, and bridges only at canal-crossings. It was laid with second-hand rails from main-line renewals—originally 60 lbs. to 68 lbs. per yard but reduced 10 per cent. in weight—no platforms, and wattle-and-daub stations. It cost a little more than £2000 per mile, not including rolling stock, and the ordinary rolling stock was used with old engines (13 tons on driving-axles). It had been intended that the speed should be 8 to 12 miles per hour, but the traffic soon increased to such an extent that it could not be dealt with, and speed was increased to 15 to 20 miles per hour.

Mr. List. The road began to go to pieces at once, the cost of maintenance became excessive, and no time had to be lost in putting down 75-lb. steel rails. Such was the result of the experiment of making a cheap, light, standard-gauge line in the newly-irrigated districts of the Punjab. But, as a matter of fact, many of the earlier lines in India, like the early English lines, had been built with a very light permanent way, and strengthened as traffic grew. The North-Western railway (originally the Sind, Punjab and Delhi railway, Indus Valley State, and Punjab Northern State railways) was originally laid with 60-lb. iron, 62-lb. steel, and 68-lb. iron and steel rails. It was relaid with 75-lb. steel about 20 years ago, and was now being relaid with 87-lb. steel rails on its heavy-traffic sections. An interesting fact was that the iron rails laid originally in 1865 cost £24 per ton, in 1875 they cost £12 a ton, and now £6 per ton was about the average for steel rails. This explained the difficulty of making a fair comparison between the cost of the earlier and the later lines. He had alreadly explained why standard-gauge rolling stock could not be made with the same ratio of capacity to gauge as metre-gauge stock, and he did not think Mr. Waring could have known the facts. Mr. List's recollection of the stock in Ceylon in 1889 was that it was very light, more like the lightest home stock. This might have been altered during the last 17 years; but with gradients of 1 in 33 and curves of 330 feet radius on a 5-foot 6-inch main line, it had perhaps not been; and this might be the reason why it was possible to make a light standard-gauge northward. He did not think a bridge was needed across to Ceylon, as the chief traffic would be coolie labour, and a good ferry would suffice for that. The Government of India would not agree to Colombo being the southern seaport for India, after what had been spent at Madras, and might be spent at Vizagapatam. Indian conditions generally were exactly the reverse of those in Australia and in South Africa. In the latter, a sparse population and light traffic permitted the adoption of light pioneer lines; in the former there was generally a dense population and heavy traffic ready to use a standard line and make it pay at starting. More than one speaker had put forward the idea that two single lines of the same gauge and between the same places, but lying some distance apart, were equal to a double line, and could be worked as up and down lines. It was an extraordinary fallacy, as this could be done only in the extreme case of military necessity, at the cost of stopping all local traffic on both lines. There were some excellent examples of this double connection on the North-Western railway, namely, between Sibi and Quetta on the frontier, which was a military line, and between Rohri and Kotri on the main commercial route to Karachi. For local traffic it was necessary that engines and

Mr. List.

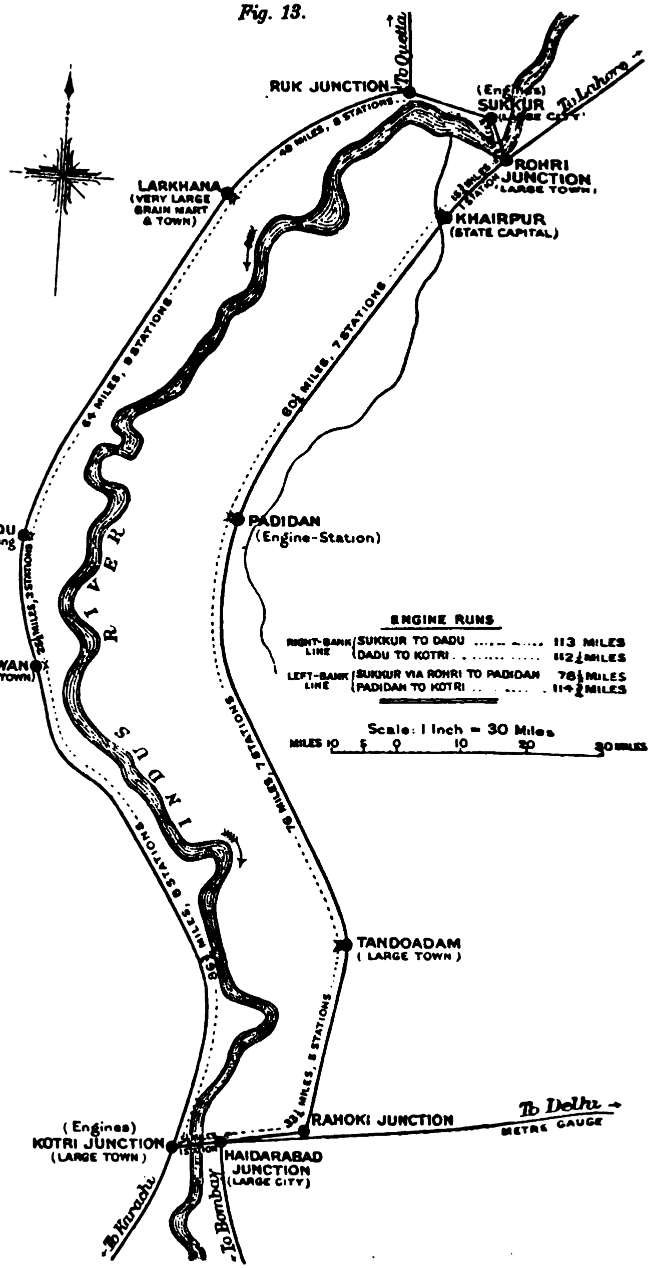
rolling stock should return the same way as they went: it was not conceivable that in ordinary circumstances station-to-station traffic on either line, was to be taken to the terminus or junction at either end and back again. *Fig. 13* would explain his meaning. It showed the actual state of affairs between Rohri and Kotri on the Indus Valley section of the North-Western railway. If these lines were to be used as up and down lines during times of heavy grain-traffic (military needs must of course be complied with at all costs) then engines must be worked thus:—

Sukkur to Padidan	1st trip.
Padidan to Kotri	2nd „
Kotri to Dadu	3rd „
Dadu to Sukkur	4th „

As the average time taken by a goods-train was 9 hours per engine-run, this meant 4 days for the round trip. Now there was a considerable local traffic between Kotri and Larkhana, for instance, and if this was to be carried via Sukkur, it meant 245 miles as against 176 miles direct. It was quite clear, therefore, that it was not commercially practicable to work traffic in this way, sacrificing as it did all the station-to-station passenger- and goods-traffic to the interests of a few of the big up-country consignors. It was a matter of regret that only one metre-gauge advocate had had the courage to express his opinions at the meeting; but Mr. Izat was undoubtedly a host in himself, and it was due to his earnest, strenuous, and persistent advocacy for the past 25 years that his line, the Bengal and North Western railway, had achieved such marked success. Had there been his counterpart 30 years ago on the standard gauge, the metre gauge would not have reached its present position in India. However, he deserved his success, and no railway man in India grudged it to him. But even Mr. Izat went wide of the mark when he compared the cost of his line per mile with that of the Oudh and Rohilkhand railway. The latter was begun in 1868, and its first length was opened in 1872. Mr. List believed the Bengal and North Western railway was begun in 1883 and opened in 1885 or 1886, a difference of about 17 years. Mr. List had served on both lines, having had charge of construction of a subdivision of 30 miles on the Oudh and Rohilkhand, and of a division of 75 miles on the Bengal and North Western. On the former line much money was spent on masonry and earthwork, and on what was called "eyewash" and "landscape-gardening"—trimming and turfing cuttings and spoil-banks; and borrow-pits were turfed and terraced to prevent rain-scours. None of this was done on the latter line, though it undoubtedly saved heavy expenditure on future main-

Mr. List.

Fig. 13.



tenance. Owing to the extraordinary rainfall and abnormal floods in 1871, after an interval of 100 years, the Saie and Gumti bridges had to be raised and doubled in length, and the earthwork had had to be so raised that, whereas Jaunpur city station was first made in a 10-foot cutting, it now stood on a 14-foot bank. But it was in the permanent way that the difference was most marked. As he had shown already, prices per ton were nearly double at the earlier date, besides the fact that the earlier line was laid with 60-lb. against 41½-lb. rails, and on cast-iron pot-sleepers, costing four times as much as the sal sleepers of the later line. Rates for earthwork, brickwork, etc., were all higher on the earlier line, as it was made by men new to India; while on the construction of the Bengal and North Western line all the divisional engineers at least were trained Indian men, and were able to work at much lower rates. The two lines were not on the same plane in this respect, and it was stretching a point to compare them as if they had been made at the same time and under the same conditions. The standard-gauge Southern Punjab railway, 400 miles in length, made in the middle nineties, had cost £4,500 per mile, but it had no large bridges, and did not provide its own rolling stock. Mr. Bury had shown that in the Argentine there was a remarkable likeness to Indian conditions, and no doubt those interested in that country would watch closely Indian developments. Captain Hearn's remarks about the native feeling regarding the gauges were very pertinent. It was a mistake to suppose that the natives of India were indifferent to questions of speed or punctuality in connection with railways. They undoubtedly were so 20 years ago, but railways had proved a wonderful educator in this respect. When the metre gauge was first started at Agra about 1870 the natives christened it "The Government toy." What would they call the still smaller gauge of 2 feet 6 inches, if it were allowed to grow in the busy and populated districts of India; and what would they say if they saw the standard gauge being converted to the metre gauge? But it was inconceivable that such a backward step would ever be taken, and the future policy would more probably be the following:—(1) Improvement of the carrying-capacity of the earlier standard-gauge lines. (2) Restriction of the metre gauge strictly to its own spheres, and conversion to standard gauge, or the laying of alternative standard-gauge lines where necessary or advisable. (3) The laying of pioneer lines of 2-foot 6-inch gauge, convertible to the standard gauge when necessary. The final averages given in the Author's Tables were simply the arithmetical means of the averages, instead of being worked out with regard to the relative magnitude of the different railways. By the courtesy of Mr. Hodson, Mr. List was able to present a revised Mr. List.

Mr. List.

COMPARISON OF CAPITAL COST AND EARNINGS OF THE 5-FOOT 6-INCH AND METRE GAUGES IN 1903.

Railway.	Length. Miles.	Cost. Lacs of Rupees.	Yearly Earnings. Lacs of Rupees. Gross.	Yearly Earnings. Lacs of Rupees. Net.	Gross Earnings per Mile per Week.	Capital per Rupee of Gross Earnings	Net Earnings. Per Cent. of Gross.	Net Earnings. Per Cent. of Capital.
Standard Gauge. (5 Feet 6 Inches.)	1	2	3	4	5	6	7	8
East Indian . .	2,198	5,011	724·4	480·4	634	6·9	66·3	9·6
Eastern Bengal .	278	806	102·2	50·8	707	7·9	49·7	6·3
Oudh and Rohilkhand . . .	1,133	1,451	142·1	73·6	241	10·2	51·8	5·7
Great Indian Peninsula . .	2,673	4,466	569·0	288·8	409	7·8	50·7	6·5
North Western .	3,741	5,592	529·0	266·4	272	10·6	50·3	4·8
Bengal-Nagpur .	1,682	2,369	155·2	70·5	177	15·3	45·8	3·0
Madras . . .	1,407	1,928	173·5	72·0	237	11·1	41·5	3·7
Bombay, Baroda and Central India . . .	828	1,587	183·8	82·0	427	8·6	44·6	5·2
Totals .	13,940	23,210	2579·2	1384·5	..	..	..	..
Averages per Mile (in thousands for cols. 2, 3, 4)	..	166·5	18·5	9·9	356	9·0	53·7	6·0
Metre Gauge. (3 Feet 3⅜ Inches.)								
Bengal and North Western . .	1,348	1,121	111·1	70·6	158	10·1	64·0	6·3
South Indian .	1,295	927	128·9	77·4	191	7·2	60·0	8·3
Burma . . .	1,337	1,301	135·8	52·2	200	9·6	38·0	4·0
Eastern Bengal .	732	695	79·1	41·2	208	8·8	52·1	5·9
Southern Marhatta . . .	1,643	1,426	95·6	30·6	112	14·9	32·0	2·1
Rajputana-Malwa	1,871	1,461	233·7	117·6	240	6·3	50·3	8·1
Jodhpur-Bikaner	824	211	27·4	14·2	64	7·7	51·8	6·7
Rohilkhand-Kumaun . .	290	139	18·2	9·7	111	7·6	53·3	7·0
Totals .	9,340	7,281	829·8	413·5	..	..	..	..
Averages per Mile (in thousands for cols. 2, 3, 4)	..	77·9	8·9	4·4	171·0	8·8	49·8	5·7

Ratios of Capital costs $\frac{166\cdot5}{77\cdot9} = 2\cdot14$. Ratios of Traffic $\frac{18\cdot5}{8\cdot9} = 2\cdot08$. Ratio of Net Earnings $\frac{9\cdot9}{4\cdot4} = 2\cdot75$.

NOTE.—One lac of Rupees = Rs.1,00,000 = £6,666. 15 Rupees = £1 sterling at date of Tables. But these values will not be correct for comparing costs in col. 2 between earlier and later lines, as the value of the rupee decreased from 2*s.* 2*d.* to 1*s.* 4*d.*—G.H.L.

Table which showed the correct averages for mileage, cost and earnings of the two gauges: from this it would be seen that the profit for the standard gauge was 6 per cent., against $5\frac{3}{4}$ per cent. for the metre gauge. The figures for mileage in this Table differed slightly from those in the Author's Tables I and II, having been taken from Appendix 38 of the Administration Report, which gave the length of line *constructed* on each railway, instead of from Appendix 18, which gave the length of line *worked*, and included portions of other lines over which running-powers were exercised. But the differences were, after all, trifling, and made no serious modification in the arguments used, though they showed that the standard-gauge was, if anything, the more profitable of the two. Mr. List.

The AUTHOR, in reply, observed that he was glad to find that the majority of those who had taken part in the discussion had acquiesced in the view that a compromise, rather than any drastic remedy, appeared to be the preferable course, and that this compromise agreed substantially with the policy now being carried out by the Government, as would be shown later. In replying to the voluminous and interesting discussion he would ask the Institution to remember that an official could do little more than weigh the evidence and let others pronounce the verdict; any personal opinion inferred must be regarded as without prejudice. Many speakers had objected to the way in which the cost of lines had been presented; they had protested against the lumping together of "actuals," even though they did not deny their accuracy; and they had demonstrated, to meet their own point of view, that the Author ought to have omitted many lines of abnormal cost, or should have eliminated many items of cost which, in their view, ought not to have been included. The Author had purposely taken actuals not estimates, although he was well aware that differences of country, military requirements, questions of policy, value of silver, famine-works, etc., had increased the cost of some lines, thus presenting an unequal comparison; but such considerations were inseparable from Indian conditions, and ideal commercial and engineering lines were not possible. He accepted the correction as to averages, but insisted that the true comparison must be one of fact, embracing every circumstance tending to enhance or diminish the cost of a railway. Mr. Waring, Mr. Burge, and other speakers had challenged the statement that the deliberate policy of Government in 1870 had obtained for India many thousand more lines of railway than would have existed at the present time had light lines of 5-foot 6-inch gauge been built. Now it had always been the case that Government admitted existing open lines to the first claim on the annual grants set aside for rail- The Auth

thor. ways, and relegated new lines to the second place. It would therefore be seen that, given two lines, one partially equipped of 5-foot 6-inch gauge, and the other completely equipped of 3-foot $3\frac{3}{8}$-inch gauge, costing about the same amount per mile, the country at large would be more speedily covered with railways by the completely equipped line. In the one case, Government would have spent a much larger proportion of its yearly grant in bringing up the incomplete line to a higher standard, by putting in heavier rails, stronger girders, platforms, stations, etc.; while in the other case, no such sudden betterments would be called for, and a substantial part of each year's grant could be made available for new lines. Sir George Bruce appeared to imply that conditions of traffic governed the choice of gauge: this might have been so originally, but not now; the gauge of the parent line and of the district were now the ruling factors. Sir George pointed out the ideal development, but admitted the cardinal error in the beginning. The deduction was that the original choice of the 5-foot 6-inch gauge had saddled India with all the trouble of want of uniformity. In answer to Sir Henry Kimber, the Author did abandon as impossible the threefold problem of conversion for an alternative compromise not leading to confusion. Sir Henry's advice to let both systems grow was eminently entitled to the highest consideration, as the verdict of an acute legal and commercial mind; and that was practically Sir Guilford Molesworth's conclusion, though it might be argued that, speed being an essential factor in dealing with the development of traffic, the wider gauge would eventually prevail, and that it would pay to change many narrow-gauge lines in the future. Mr. Shelford thought a conversion of gauge never occurred, but in India the Bengal-Nagpur line began operations by pulling up all the metre-gauge lengths on its system, and the frontier 2-foot 6-inch lines were under gradual alteration to the widest gauge. If a cheap and flexible line was essential, there was a good deal to be said in favour of adopting the smallest gauge that would take the existing traffic, because, the greater the difference, the sooner conversion took place. Mr. Hodson's conclusions were in the main sound; but when he denied to the metre gauges, which had more than a thousand miles behind them and were within easy distance of seaports, access to the latter, he was putting a check on their utility that could not be reasonably accepted; nor would companies under contract with the Secretary of State lightly forego their dividends for an ideal system. The Author was glad to hear from Mr. Izat that metre-gauge lines could be doubled for £2,000 per mile; if that was so, the case for doubling that gauge was greatly strengthened; but apparently no increase of

rolling stock was made in the case cited. From Mr. Bury's remarks the Author gathered that the conditions in South America and Egypt were not dissimilar from those obtaining in India, and that uniformity on its own merits was not considered likely to supersede the commercial test of the survival of the fittest. Mr. List's views were so nearly met by the existing position of the gauge question in India that the Author had only to point out that when Mr. List deprecated two gauges running into a port because grain was not loaded direct, he apparently forgot the dreadful system of garbling which prevails in India. The Author hoped that soon this relic of the past would be swept away and direct loading come into operation. None of the speakers appeared to have attached sufficient importance to the various contracts now running, which expired at remote periods and presented a serious difficulty to any plan of uniformity, although a distinct advance was being made in this direction. Much stress had been laid on the necessity of a second broad-gauge track between Ahmedabad and Delhi. This was afforded by the new 5-foot 6-inch line from Nagda through Kotah to Muttra and thence to Delhi, which was approaching completion. When it was opened, the effect might be to reduce the through traffic on the Rajputana-Malwa railway. Was it not premature, therefore, to advocate altering that line in any way until the effect of its broad-gauge competitor was actually known? The Raipur-Vizianagram line was definitely decided to be constructed on the 5-foot 6-inch gauge. The Bombay-Sind connection also had been settled to be of that gauge. Lastly, the link connecting the north and south metre-gauge systems would run probably from Khandwa to Nandod and from Haidarabad to Guntakal. Connection on the 5-foot 6-inch gauge with Ceylon was complicated by that island being under the Colonial Office and not under the India Government, by questions of alleged necessity for a harbour at Pambam, and by the various contracts with the Madras and South Indian railway-companies. Looking, therefore, at the summary of criticisms in a general way, the members of the Institution would find that the present position in 1906 was in accord with the opinion of the majority. The prosperity of the Indian railways appeared to be assured and increasing, the net surplus profits on all open lines, after paying all interest charges for capital and for a sinking fund to extinguish the debt of purchased companies, having been:—

The Author.

	£
1900-1	325,124
1901-2	846,616
1902-3	228,949
1903-4	860,669
1904-5	2,105,438

thor. In seasons of good normal rainfall, the railways were benefited by increased internal and foreign business; in periods of local scarcity, they still found that the misfortunes of the land brought them large receipts, it being a cardinal principle that rates should not be lowered, but the movement of food-grains left to the natural requirements of trade. Visitations of plague alone seemed to affect the railways adversely. Therefore, weighing the railways in the balance of general usefulness to the country and fair return on capital, might not those who were responsible for the railway-gauges of India feel, while admitting errors in the past, that a good record could be shown, and that the yearly increasing necessity for higher speeds, and for greater comfort and conveniences, would gradually bring about uniformity? England waited nearly 50 years before the Great Western railway, after having a mixed gauge for some time, finally abandoned the 7-foot gauge. Then the United States and Canada followed suit. South America and Australia were still considering the cost, and waiting like India until the advantages of a uniform gauge would be forced on them by commercial necessities.

Correspondence.

ghey. Colonel G. F. O. Boughey, R.E., observed that modern conditions and practice had shown that the assumed much heavier cost of standard-gauge lines, which had been the reason for introducing metre-gauge lines into India, was largely, if not entirely, a fallacy; for in easy country standard-gauge lines had recently been constructed at a cost little more than that of metre-gauge lines. The Southern Punjab railway, for instance, upwards of 400 miles in length, in exceptionally easy country, had been built at a cost, excluding land and rolling stock, of little more than £3,000 per mile, or, including everything, say, £4,000 to £4,500 per mile. This was but little above the cost of a metre-gauge line in similar country; and yet the Southern Punjab railway was capable of carrying, at a moderate speed, goods-vehicles with a gross load of 12 tons per axle, which could run over trunk-lines to the ports. Uniformity was desirable, but, looking to the future, a country of such immense distances and great prospects, and wherein the principal trunk-lines serving the ports and coal-fields were already laid on the standard gauge, was no place for lines of inferior speed and carrying-capacity. What had to be aimed at, therefore, was a system of double lines on the standard

gauge, beginning at the ports and coal-fields, and running backwards as far as the amount of traffic would justify it. The delay and consequent cost of dealing with heavy traffic on a single line was considerable, and this must be taken into account in deciding when and how far a double line on the standard gauge should be laid, which was a matter that could not be determined by any mathematical formula. The cost of transhipment was exceptionally low in India, and the necessity for it did not form any practical impediment to the free flow of traffic from the extreme limits of the metre-gauge lines to the ports, or any appreciable addition to the cost of transport from the place of origin to the European market. There seemed, therefore, to be no substance in the claim that because the metre-gauge lines had originated a fairly substantial traffic, it should be carried through to the ports on the metre gauge, merely to save the cost of transhipment. Still less did it seem right that heavy expenditure should be incurred in constructing long lengths of line solely, or mainly, to save the cost of transhipment. Where the amount and cost of transhipment was considerable, there was a clear indication that the standard gauge should be carried farther back. The port of Marmagao, now served exclusively by the metre gauge, might perhaps continue to be served by single, or as far as necessary double, lines on that gauge, for it did not seem that traffic was likely to flow to that port from such considerable distances as to the other ports. Madras was also in some respects exceptional. It already had lines of both gauges running into it, and it was alone in the fact that rail-borne traffic was loaded into boats, so that it was not necessary to intermix the gauges in order to serve any particular vessel. If, therefore, the facilities of the port were such that the two gauges could continue to be conveniently and separately accommodated, and if the traffic of the South Indian system could be adequately dealt with by doubling the metre gauge as far as necessary, there seemed to be no reason why that gauge might not be retained for that system. With these possible exceptions, he ventured to deprecate strongly the introduction of the metre gauge into any other port. The metre gauge must either be mixed up with the standard gauge, so as to give it equal access to every vessel, or it must be placed behind the existing standard gauge—a position which it would not likely occupy for long without complaint, involving as it would costly and difficult arrangements for passing all its traffic across. The cost of transhipment at an up-country station was as nothing compared with the cost, delay, and confusion inevitable from the introduction of a second gauge into the busy scene and limited space available at the ships' sides at a port. On this point he wrote

Col. Boughey. with some experience of the actual work of dealing with export and import traffic at the port of Karachi, and with some knowledge of the same work as carried out at Calcutta and Bombay. In short, the great and growing export traffic should flow into each port in one broad stream, and not by each separate trickle finding its own way down.

Mr. Brunton. Mr. J. FORREST BRUNTON regretted that the Author nowhere gave expression to his own views, or even an indication of his opinion as to the necessity of having now, or at some future date, one gauge only for the railways of India. The Author's position as chairman of the Railway Board in charge of Indian railways might be the cause of this reticence, but as that position had not prevented him from bringing the subject before the Institution, it was a pity if it had prevented him from expressing his views for or against conversion. In Mr. Brunton's opinion, conversion from the narrow, or metre, to the standard, or broad, gauge must come eventually, and, as every year's delay added to the number of lines to be converted, and increased the expenditure that would ultimately have to be incurred in order to rectify an error that ought never to have been committed, the sooner it came the better. The metre-gauge lines were originally intended—or it might be more correct to say that those who were responsible for their introduction said they were intended—to be only feeders for the main standard-gauge lines. That they would be allowed to extend into large and important independent systems had never been contemplated officially, although, no doubt, those who had given the subject due consideration had seen the danger of their so extending, and this danger was, equally without doubt, one of the reasons why their introduction had been opposed by many of those best able to form an opinion on the subject. Since its introduction, the metre-gauge extension had more than kept pace with the extension of the standard gauge. When the first metre-gauge railway was opened in 1873, the standard-gauge mileage amounted to 5,576¼ miles.[1] At the end of 1904 the mileage was: standard gauge 14,733, and metre gauge 11,562 miles.[2] Thus, in the 31 years which had elapsed since the introduction of the metre gauge, 11,562 miles had been laid on that system, against only 9,157 miles of standard gauge. That the metre gauge was still extending practically twice as quickly as the standard gauge could be seen by a comparison of the mileage of 1899 with that of 1904. During this period the

[1] Minutes of Proceedings Inst. C.E., vol. xcvii. p. 107.

[2] "Administration Report on the Railways in India for . . . . 1904, by the Railway Board," p. 1. Simla, 1905.

extension of the standard gauge had been a little less than 3 per cent. Mr. Brunton
of the mileage open on the 31st March, 1899, while the metre-gauge extension was a little less than $6\frac{1}{4}$ per cent. The importance of the question raised by the Author could therefore hardly be exaggerated, as the evils of a dual gauge were daily becoming more acute. It was not a question of the relative value of particular gauges. It was possible that a metre gauge might meet all the traffic requirements of India, or that it would have been wiser to have originally fixed on a metre, or 4-foot 6-inch, or 4-foot $8\frac{1}{2}$-inch gauge, instead of a 5-foot 6-inch. But this was not the question to-day. The standard gauge of India had been fixed at 5 feet 6 inches more than 50 years ago, and there were now nearly 15,000 miles of open line on this gauge. Was it seriously proposed to convert it to the metre gauge? If not, there could be no object in altering it. Its conversion to any other gauge would not remove the evils of a dual gauge, unless the metre gauge were also converted, in which case the metre gauge could as easily be converted to the standard 5-foot 6-inch gauge as to any other. The important question was, was India always to be saddled with the evils of a dual gauge? If not, the sooner steps were taken to stop further construction on the narrow gauge, and to gradually convert that gauge to the standard gauge, the better A glance at any railway-map of India showed only too clearly the evils that a dual gauge had already caused. Thirty-five junctions between standard- and metre-gauge lines could easily be counted, at each of which there was experienced the inconvenience, delay, and cost that were inseparable from the transhipment of passengers and goods. Was it not time, then, to put a stop to any increase in the number of these barriers to the free transport of passengers and goods, and to arrange for their gradual removal? So long ago as March, 1889, Major-General (now General Sir E. C. S.) Williams stated that, with more than 5,000 miles of narrow-gauge line, the objection to break of gauge cut both ways when extensions were contemplated.[1] Those who favoured the narrow gauge probably thought that this argument had been greatly strengthened with 11,562 miles of metre-gauge railway now open. But Mr. Brunton ventured to think that if the necessity or advisability of adhering in the future to one gauge were admitted, few would prefer the metre to the standard gauge. There could be no doubt that, viewed merely as a means of transport, the standard-gauge railway was superior to the metre-gauge. A metre-gauge line was capable of carrying a heavy traffic at a fair speed, and it was by no means the toy some considered it; but it could

[1] Minutes of Proceedings Inst. C.E., vol. xcvii. p. 165.

Mr. Brunton. not compete with a standard-gauge line in either carrying-capacity or speed, and it was not reasonable to expect it to do so. Consequently the rational course appeared to be to retain the 5-foot 6-inch gauge as the standard, and to give up the metre gauge. The comparison of first cost given by the Author in Tables I and II, while no doubt correct as far as it went, was misleading, as it did not clearly bring out the fact that the standard of construction of the metre-gauge lines was so inferior to that of the standard-gauge, that no fair comparison could possibly be drawn without making liberal allowance for this. In the Paper the Author admitted that at no time had there been any serious attempt to lay down an inexpensive standard-gauge line equipped with suitable light rails, rolling stock and station-accommodation; but the fact that the metre-gauge railways had generally been built on cheaper lines than the standard-gauge was not elsewhere alluded to. Mr. F. J. Waring, in 1889, showed[1] that, on the standard-gauge lines then open, the cost of the larger bridges alone increased the cost per mile by nearly Rs.11,600, while on the metre gauge the increased cost on this account was only Rs.1,416. Taking the rate of exchange at 2*s.* per rupee, as it probably was when the greater part of the works referred to were made, this meant that the cost of the large bridges, excluding cost of heavy approach-works, had in 1899 enhanced the cost per mile of standard-gauge lines by more than £1,000 per mile over metre-gauge lines. In addition to this the standard gauge was made to bear the cost of rails 70 per cent. heavier than those on the metre-gauge lines; and, further, the very heavy expenditure necessarily incurred on the pioneer lines of India, and on the frontier lines such as the Peshawar and Quetta branch of the North Western railway, was all included in the figures given in Table I. A fair comparison should exclude all these charges from the standard-gauge figures, when it would probably be found that for lines built to the same standard, having the same weight of rails, and capable of carrying equal axle-loads at equal speeds, the standard gauge would cost less than £1,000 per mile more than the metre gauge. If, therefore, the 11,562 miles of metre gauge which had been constructed since 1873 had been made on the standard gauge, but of lighter construction, the extra cost would have been less than £11,562,000—not an exorbitant sum to pay for the advantage of uniformity of gauge. This extra expenditure would have involved no positive loss; it would merely have reduced the return on capital from 6 to 5 per

---

[1] Minutes of Proceedings Inst. C.E., vol. xcvii. p. 114.

cent. It was true that a standard-gauge line with light rails, etc., made lighter engines and lower speeds necessary over the section so constructed; but surely this would be immeasurably less inconvenient and less costly, and would involve less delay, than the transhipment of passengers and goods; and obviously the cost of bringing such a line at any time up to standard conditions was nothing compared with the cost of converting a metre-gauge into a standard-gauge line, to say nothing of the delay to traffic and the general inconvenience that would be caused during the conversion. Mr. Brunto

Mr. C. E. CARDEW remarked that the use of the term "standard" gauge savoured of political affectation. It was never used in India by railway-authorities outside Government official circles; in ordinary speaking and writing the term was always "broad," or "5-foot 6-inch" gauge. The Author asserted that the narrow-gauge lines did not in general serve metre-gauge lines, but had been built as feeders to standard-gauge lines. A noticeable exception to this rule was the Darjiling-Himalayan 2-foot line, which had been planned as a feeder to the Northern Bengal metre-gauge railway. Recently it had been proposed to build a 2-foot 6-inch line into the Southern Shan Hills in Upper Burma as a feeder to the metre-gauge lines of that country. If this break of gauge were really justifiable, it would be hard to defend the introduction of the larger of the two small gauges, a saving of merely $9\frac{3}{8}$ inches. So long as this sort of thing was permitted, it was useless to deplore, as done by the Author, that no serious attempt had been made to preserve uniformity of gauge by building inexpensive broad-gauge lines equipped with light rails, rolling stock, and station-accommodation. Historically, however, he was not quite accurate, as the Oudh and Rohilkhand railway had been originally built very lightly—so much so that the neighbouring East Indian railway, about 30 years ago, declined to accept its wagons in interchange. This, of course, had resulted in their being replaced by wagons of ordinary heavy build. As to private ownership of railway-wagons, no responsible railway-official with experience of traders' wagons in the United Kingdom and in other countries where they were permitted, would ever willingly admit them into India, as they always tended to become a serious source of difficulties in working. The schemes for their introduction referred to by the Author had deserved to fail, for they had been proposed not by the actual traders needing them (such as colliery-owners and grain-dealers), but by certain companies, to be incorporated as public carriers, which owned the wagons and hired them out. Under such a system of private ownership, compared with that of traders' wagons as hitherto practised, the difficulties of the railways would be Mr. Cardew

Mr. Cardew. greatly enhanced. In referring to the broad gauge as being more efficient than the narrow in respect of carrying-capacity, the Author clearly used the term "more efficient" as synonymous with "larger"; for it was universally conceded that a metre-gauge wagon could always be built of greater efficiency in its tare-to-load ratio than a broad-gauge wagon. This was due solely to the permissible relative overhang in the former being so much larger than in the latter; in fact, on the Indian 5-foot 6-inch gauge the permissible width of car-body was no greater than on the Canadian 4-foot 8½-inch gauge. He had pointed out what the metre-gauge was capable of in this respect 2 years ago, in the discussion on Steel Railway-Wagons.[1] In remarking that, so far, all the metre-gauge lines were single-tracked only, the Author had overlooked the Burma railways, which at present had 16½ miles of double track, and 1 mile of treble track; while a much larger extension of double track was to be provided in the near future. With reference to the Author's remark that it was significant that the metre gauge carried the larger average passenger train-load, this was probably due merely to the broad gauge having a more frequent train-service, the rigid economy practised on the metre gauge (which generally comprised the poorer lines of the country) tending to the crowding, not to say overcrowding, of the trains. In his anticipation of little difficulty in converting existing rolling stock from the metre to the broad gauge when necessary, the Author would scarcely be supported by engineers having any knowledge of the actual difficulties to be overcome. So far no such conversion had been attempted except in a few isolated cases, where for merely temporary purposes the bodies of a few passenger-vehicles had been put on broad-gauge underframes. In stating that the cost of transhipment between the two gauges was equivalent to an extra haulage of 20 miles, the Author omitted to state on which gauge the haulage was to be reckoned; but in the evidence given before the Parliamentary Committee of 1884[2] regarding the extension of railways in India, the Consulting Engineer for State Railways to the Secretary of State for India (Sir A. M. Rendel, K.C.I.E., M. Inst. C.E.) estimated the cost as being approximately equivalent to having an additional 10 miles added to the Rajputana-Malwa system, which in that year had three transhipment-stations (Ahmedabad, Agra, and Khandwa). This mode of expressing the cost seemed to be better than that in terms of haulage merely.

[1] Minutes of Proceedings Inst. C.E., vol. clviii. p.

[2] "Report from the Select Committee on East India Railway Communication," p. 368. London, 1884.

Mr. R. W. EGERTON considered that the two questions asked by the Author on p. 3 should be answered in the negative. After pointing out how the policy of confining the metre-gauge railways to certain defined areas has not been adhered to, with the result that that gauge had spread over the country, and in some cases had become competitive with the standard (5-foot 6-inch) gauge, the Author went on to state that this competition had, on the whole, been of benefit to the country and to trade. But Mr. Egerton ventured to point out that in a country which was still undeveloped and was crying out for railway-extensions, the construction of competitive lines was not called for, and should not be encouraged. Moreover, it must be remembered that the Indian Government was, practically speaking, the owner of all the lines and had control of all the rates. Such being the case it would appear that, if the Government exercised its control for the benefit of the people, the necessity for competitive lines disappeared. Indian railways of the present day presented a somewhat melancholy object-lesson in railway economics. It might naturally be asked why, when Government was practically the owner of the metre-gauge lines, it had been unable to withstand their demands for access to large centres of trade. The answer was that the working of the lines had been given over to companies who had deposited a fixed sum of money, on which Government had guaranteed a certain rate of interest plus a certain percentage of surplus earnings. The ratio of this deposit to the capital cost of the lines varied of course on different lines, but in no case did it exceed a quite small fraction. The companies were represented by boards whose offices were in London; and it was due to the pressure exercised by these boards that the demands were granted. It was thus that competitive lines had come into existence. Some of these lines had no *raison d'être* whatever, except for the purpose of linking up two metre-gauge systems; and sometimes there was not even that excuse. A very instructive example was the Cawnpore-Burwhal metre-gauge link, which was laid on the same formation as the Oudh and Rohilkhand railway between those points for practically the whole distance of 80 miles. The Lalkua-Kashipur line, in the United Provinces, now under construction, and the Benares-Allahabad line, now under survey, were further examples of unnecessary lines; and it might safely be predicted that, unless some definite policy with regard to metre-gauge extensions was formulated and adhered to, there would be many more examples of unnecessary metre-gauge lines in the future. There could be no doubt, too, that metre-gauge administrations would never be satisfied until they obtained access to the ports of Bombay, Calcutta,

r. Egerton. and Karachi. The expense attendant on such a course, in the construction of unnecessary lines, would go far towards paying for the conversion of these lines to the standard gauge. It remained to consider, therefore, the three suggestions for conversion given by the Author. The idea of converting all 5-foot 6-inch gauge lines to the metre gauge might be abandoned at once. First, because the cost of conversion would be a capital charge, and it would be economically unsound to substitute an inferior means of transportation for a superior one, at the same time increasing the capital cost of the undertaking. Secondly, because the metre gauge, on account of the low limit of speed attainable, was an unsuitable gauge for large trunk-lines. The second suggestion, that the metre-gauge lines should be converted to the standard gauge, had something to recommend it. The policy to be adhered to, if such a course were decided on, would be to rigorously exclude the metre-gauge lines from all the three ports enumerated above, and to gradually convert all existing metre-gauge lines directly the volume of traffic justified the conversion; and, in order that there might be no opposition from the boards of the metre-gauge companies, a clause providing for this conversion should be added to all their contracts when these contracts came to be renewed. Only by some such measures as these would it be possible to control metre-gauge construction in India, and make that gauge what it was originally intended to be, the handmaid of the standard gauge. But the Author's third suggestion, namely, the conversion of both gauges to the English gauge had most to recommend it. Its advantages were clear. The claim, often justly raised, that the cost of the 5-foot 6-inch gauge was so high that the metre gauge should be accepted on certain lines, would disappear. India would reap the incalculable advantage of being able to adopt all that was best in the designs of locomotives and rolling stock, station-machinery, etc., which English practice had evolved and perfected. The cost of all kinds of rolling stock would also be less. The work of converting 30,000 miles of railway was at first appalling in its magnitude; but, after all, what did it amount to? As regarded regauging the 5-foot 6-inch lines, an alteration in the tie-bars of the pot-sleeper road and a respiking of the rails or chairs on the wooden-sleeper road was practically all that was required, and on the metre-gauge lines the same, with perhaps in some cases renewal of the wooden sleepers. The whole difficulty, indeed, was tied up in the question of the conversion of the rolling stock; and the locomotive problem was the most difficult of all. But this difficulty could be overcome in the same way as the Great Western railway had overcome it at home some years ago. The

designs of all locomotives and rolling stock in the future should be such that the conversion could be easily effected, and then, when the time came—say, 10 years hence—the conversion should begin from some fixed point, Tuticorin, for example, and be gradually extended year by year till the whole scheme was completed. The more this thorny question of gauges was contemplated, the more did the conviction grow that it was only by the adoption of the English 4-foot 8½-inch gauge that the gauge difficulty in India was to be solved. Mr. Egerto

Mr. G. C. GODFREY observed that the Author's interesting account of the struggle of the gauges in India threw much light on what to an outsider would appear to be the grave mistakes of the earlier railway-authorities in India. That there should be four different gauges in a country like India, where the Government had control over the whole of the railways by its powers of sanction and veto, seemed absurd; but the Author showed how the apparent absurdity had grown up, and that there were good reasons for it. The broad-gauge line cost two-and-a-half times as much as the metre gauge; therefore, had the Government of India pinned its faith to the broad gauge, there would now have been at least 7,000 miles less line open for traffic, for the same capital expenditure. On the other hand, the capacity of the broad gauge was shown to be about double that of the metre gauge, and the broad-gauge single lines were in most cases working nearly up to the limit of their capacity; therefore, had the Government of India adhered to the metre gauge only, the trunk-lines would have had to be doubled, and in some cases even quadrupled, while the trade of the country would have suffered from delays in transit, and from the actual incapacity of lines to carry the traffic until doubled. The great mistake had been made at the beginning in allowing two gauges, and in adopting either such an expensive and heavy gauge as 5 feet 6 inches, or such an inefficient one for heavy traffic as the metre. An intermediate gauge, the English 4-foot 8½-inch for choice, would have served all purposes, it could have been used with greater ease and far less cost than the broad gauge for hilly country, and its carrying-capacity would not have been 25 per cent. less; while as compared with the metre gauge its efficiency would have been at least 75 per cent. more. The saving in cost as against the 5-foot 6-inch gauge would have assisted in meeting excess in cost over the metre gauge. But the question for discussion was not so much the mistakes of the past as the line of policy to be adopted in the future. Mr. Godfrey considered that both the Author's questions (p. 3) should be answered in the affirmative, but that the last sentence of question No. 2 should be omitted. His reasons Mr. Godfre

Mr. Godfrey. were briefly the following:—The open-line mileage for 1904 was 14,733 miles of 5-foot 6-inch gauge, 11,562 miles of 3-foot $3\frac{3}{8}$-inch gauge, 942 miles of 2-foot 6-inch gauge, and 328 miles of 2-foot gauge, and in addition there was sanctioned for construction, 306, 212, 251, and 81 miles, respectively. The cost of conversion of 15,039 miles of broad gauge to the metre gauge, or of 11,774 miles of metre gauge to the broad gauge, or of 26,813 miles of both gauges to the 4-foot $8\frac{1}{2}$-inch gauge would entirely absorb all the money available for expenditure on railway-construction in India for some years, and in the meantime the trade and progress of the country would suffer severely from the want of new lines to develop the large areas not yet served by railways. The conversion of the metre gauge to the 5-foot 6-inch gauge would over-capitalize many of the metre-gauge lines, and the owning companies would naturally object to the loss of profit. Moreover, the conversion of either gauge to the other, or of both to the 4-foot $8\frac{1}{2}$-inch, would, as the Author showed, have to be carried out gradually, the main line of a system being taken in hand first and converted section by section : this would lead to great confusion at branch junctions, owing to transhipment, and traffic towards the sea-coast would probably have to undergo transhipment two and even three times while conversion was in progress. It should now be finally recognized that there were three gauges, the 5-foot 6-inch, 3-foot $3\frac{3}{8}$-inch, and the 2-foot 6-inch gauge, and that any scheme for bringing about uniformity was impracticable. The small 2-foot gauge should be discountenanced except for tramways; there was only 409 miles of such line in existence or under construction, and these lines were generally small feeders and tram-lines or hill railways as such. These did no harm to the railway-system of India; but no new lines on this gauge should be sanctioned as railways except for short extensions of existing 2-foot lines; and it should be the policy of the Government to convert all the 2-foot lines to the 2-foot 6-inch gauge, whenever that course was possible without increasing the capital to such an extent as to render the line incapable of earning a fair return on its capital. The broad- and the metre-gauge systems should be regarded as two complete and independent systems, each to be fed by branches of its own gauge where possible, or by branches of 2-foot 6-inch gauge where the physical nature of the country and its promise of traffic rendered the cheaper gauge necessary; but as a rule the 2-foot 6-inch gauge should be restricted to feeders for the broad gauge, and only under very special circumstances, such as mountain railways, should it be permitted for feeders to the metre gauge. Further, on all new 2-foot 6-inch gauge feeders to broad-gauge lines the masonry

of bridges should be built to dimensions suitable for conversion to the broad gauge, and the smaller girders up to 6 feet span should be of the broad-gauge type. To render the metre-gauge system complete, it should be given every facility for its traffic to reach the ports of Calcutta, Bombay and Karachi, without actually receiving direct access. The first step as regarded Calcutta would be the bridging of the Ganges at or near Sara Ghat: transhipment between the broad and the narrow gauge could then be effected at a minimum tax on traffic; and, in view of the expense of laying a double gauge on the Port Trust railway and connections in Calcutta, it would be necessary to retain permanently the transhipment-station at the river, and, when required by traffic, to lay an additional broad-gauge line into Calcutta. This principle applied in the same way to the ports of Bombay and Karachi. Transhipment was a very small tax on traffic, provided platforms and sidings were suitably arranged; the average cost at Ahmedabad had been shown to be 5½*d.* per ton, and this should be capable of considerable reduction; but even at that figure, the equivalent extra lead of 20 miles was not much on traffic which was being carried 400 miles or more to the coast, and the interest on capital outlay in bringing the second gauge to the port, and the extra expense of working two gauges at the port, would probably constitute a tax on trade equal to or greater than 5½*d.* per ton. In order to connect the northern and southern systems the link mentioned by the Author between Khandwa and Hotgi should be started at once, and a branch should be made from the point of junction with the Haidarabad-Godavari line (probably Sailu) through Ahmadnagar to a junction on the Great Indian Peninsula railway, such as Kalyan, where transhipment would take place for Bombay. This would be an expensive branch, owing to the crossing of the Western Ghats, but it would be necessary as an outlet for traffic to the seaport from the new Khandwa-Hotgi link and from the Haidarabad-Godavari Valley line. The latter line was at present entirely isolated from its own gauge, and should never have been sanctioned as a metre-gauge line; but since it was in existence, the southern portion of it would serve as a feeder to the two extensions advocated above, and, when the Sailu-Kalyan branch was ready, affording easy access to Bombay, it would probably be found necessary to convert the northern portion between Sailu and Manmad to the broad gauge, as it would no longer be of any use as an outlet for the Godavari Valley produce from the country south of Sailu towards the sea-coast. In all other cases where rivers intervened at points of transhipment between the gauges, bridges should be built; a programme for this could be prepared arranging the bridges in order of importance, and allowing for

ffrey. one or two, according to the cost, being started each year. In the future no isolated metre-gauge lines should be constructed; the only extensions permitted on that gauge should be feeders to or extensions of the existing metre-gauge systems.

Lart. Mr. F. A. Lart observed that one point brought out very clearly by the Paper was the decided relative superiority of the metre gauge in every particular. This in itself was a strong argument against the broad gauge. He thought the 5-foot 6-inch gauge stood self-condemned, and that had the gauge been 5 feet there would not have been the discrepancy, either of first cost or —much less—of general efficiency, between the two gauges; and, incidentally, conversion of one gauge to the other would have entailed less difficulty and less cost. As things stood at the present time, and with the impending unknown development of the Indian railways, which would apportion itself between the two gauges— perhaps equally, but possibly to a larger extent on the metre gauge— and looking at the intricate network of broad- and metre-gauge lines, it might be prophesied that no general conversion of either system to a standard gauge, broad or metre, was either probable or indeed possible, as the cost would be prohibitive, even to the growing prosperity of India; and that India was therefore doomed to the dual system of railway-gauges, with all its disadvantages. That unfortunate state of affairs was aggravated by the existence of two minor gauges, namely, the 2-foot 6-inch and the 2-foot, which served as feeders. If these were looked upon as pioneers of the broad gauge, and not adopted in connection with the metre-gauge lines, the discrepancy between the two, and the difficulty, if not impossibility, of conversion, considering the nature of the country they were said to occur in, was obvious. Given any trunk-line or connected system such as a country like India afforded plenty of scope for, the development of narrow-gauge lines to act simply as feeders to the trunk-lines was logical and desirable. But when railways were put down in such a country not on any well-defined plan of extension or combination, and with two or more gauges connecting and even intermixing, confusion and difficulty were the inevitable result. It would seem that any scheme of conversion, whether local or general, would absorb so much time and so much money as to hinder seriously the natural development of the Indian railways. If any plan of conversion were seriously needed and entertained, the decision should be made and acted upon forthwith. His own opinion was that the broad gauge should give way to the metre gauge, which should become the standard; it would suit India better than the excessive gauge of 5 feet 6 inches, despite all the possibilities of the

Mr. Lart.

future. He thought that the analogy of the Great Western dual gauge would hold good in regard to these two Indian gauges. But whereas in England the discrepancy between the two gauges had been roughly, 35 per cent., in India it was, roughly, 60 per cent.; and if in a highly-developed country like England such a discrepancy was found inadmissible, the 7-foot gauge excessive, and the conversion of the narrow gauge to the broad gauge impracticable (not solely on account of the broad gauge being an isolated minority), then surely the moral was that the Indian broad gauge should give way to the metre gauge, the lower cost of which would enable a double line to be put down. There were many practical reasons in favour of this, apart altogether from the question of capital cost. India was probably not a country that called for rapid travelling. It had been, and could be, europeanized up to a certain point; but still it had remained, and must ever remain, an eastern country conducted on eastern lines of life; and therefore the metre gauge would be sufficient in point of speed, especially as very fair maximum and average speeds were quite feasible. As the Author showed, the average speeds of the metre-gauge lines were very little less than those of the broad-gauge lines. Indeed, the efficiency of the metre gauge in every respect—including carrying-capacity—was very little less than that of the broad gauge, and relatively it was considerably higher. For some time Mr. Lart had had charge, under the consulting engineers, of the construction of large numbers of broad- and metre-gauge locomotives for the Indian railways, and he had been struck with the relatively low and high powers and efficiencies of the broad- and metre-gauge engines, respectively. Of course there was much greater scope for development in the case of the broad-gauge locomotives; but surely that pointed to the gauge being excessive for the requirements of the country. The cost of conversion from metre gauge to broad gauge in one of the instances cited by the Author, namely, £2,867 per mile, seemed to him rather low. The several items were not easy of analysis; but the cost of the rolling-stock conversion, £667 per mile, seemed rather small, as it represented, necessarily, new locomotives and new carriages and wagons for that particular length of line. The cost of, say, five locomotives for working the 50 miles referred to would be about £17,500 complete on rails, leaving £15,850 for new carriages and wagons; while the value of the old locomotives, carriages, and wagons would be little more than scrap value, say £3,000. Similarly, conversion from broad to metre gauge would involve considerable loss in value of stock broken up, and not much less expenditure for new rolling stock. It was difficult to understand why, with conversion from the metre to the broad gauge presumably

Lart. in view, the tunnels alone had been built to suit the broad gauge, while the station-dimensions and loading-gauges generally had been retained on the dual system; because the expense of increasing the capacities of station-buildings alone would perhaps be as much per mile as the extra cost of the larger tunnels. The question of bridges and their replacement, strengthening, or widening for broad-gauge traffic was a serious one. Indeed, only in a few favourable instances would strengthening or widening of bridges be possible. In the case of a single track, no doubt a metre-gauge bridge would take a broad-gauge track so far as width and clearances were concerned. But the carrying capacity was another matter; and with the development of the broad-gauge locomotive the general capacity of even the existing broad-gauge bridges was already in question. It looked as if all the Indian railways were marking time, each waiting for the others to begin the task of conversion. But any conversion that was decided upon would have to be general, and indeed compulsory; for the existing confusion would be increased indefinitely if some systems were converted to the broad gauge and others to the narrow gauge. Considering the gradual acquisition by the Government of India of all the railways, it was not difficult, studying the railway-map presented in the Paper, to devise a complete scheme of trunk-railways, by co-ordinating the existing lines of the broad or the narrow gauge, and frankly accepting the tributary lines as mere feeders, their gauges remaining unaltered. Looking at the problem in this light, the relative existing mileage of broad and of metre gauge was not perhaps of so much importance as the Author suggested; the chief difficulty would seem to lie in the fact that certain towns had developed from minor to first-rate importance, and were developing—as others also would do in time—simply by reason of the railways that served them. Of these towns Marmagao was instanced by the Author, the importance of which port would seem to require, in connection with the existing through communication between Bombay, Madras, and Calcutta on the broad gauge, the conversion to that gauge of the Poona-Marmagao-Bangalore, and the Marmagao-Guntakal-Bezwada metre-gauge lines; also the conversion of the metre-gauge Karachi-Agra and Ahmedabad-Delhi lines to the broad gauge, thus linking up Karachi and Calcutta, Bombay and North-West India. The existing metre-gauge lines north and east of the Hooghly and Ganges rivers might be left as they were. But any re-arrangement of this kind would be a temporary solution of the problem of trunk-line intercommunication, if the lines so converted, and all others built in the future, whether broad or metre gauge, were not made double. This doubling should be taken in hand simultaneously with the conversion, thus

dealing with the difficulty in a drastic and permanent fashion, to the ultimate saving of considerable trouble and expense and of general disorganization of the railways affected. The question of cost was naturally a very serious one; but the circumstances of the Indian railways and the present needs of India were such as to demand, to justify, and to provide whatever finances might be required, in the certain knowledge that, as in the case of the heavy expenditure on public works in Egypt and the Sudan in recent years, a speedy and bountiful return of general prosperity was assured, since the economic development of India, as it had arisen from the railways of the country, was also entirely dependent upon them. Mr. Lart.

Mr. HENRY B. MOLESWORTH observed that the Author put forward three proposals for securing uniformity of gauge, the cheapest of these involving an expenditure of £2,500 per mile in converting 11,400 miles of metre-gauge railway to the broad gauge, or a sum of £28,500,000 at the lowest estimate. This could hardly be put forward seriously, as a practical suggestion. If the quantity of goods transhipped from the metre gauge to the broad gauge at all the transhipment-stations in India were assumed at 1,000,000 tons annually—which was probably much above the actual amount—and if the cost of transhipment were taken at 9*d.* per ton, there would be a yearly expenditure of £37,500, whereas the interest on £28,500,000 at 3½ per cent. would be £997,500. Uniformity of gauge was very desirable, but it was possible to pay too dearly even for desirable things. The initial mistake of introducing a break of gauge had been made, and the result had been that in 30 years the metre-gauge systems had assumed such dimensions that a drastic and wholesale policy of conversion to the broad gauge was beyond the range of practical financial achievement. The remedy for the break of gauge in India was not to be found in wholesale conversion, but in accepting the present state of things, and in taking each case on its merits and making the best of it. On p. 13 the Author said that when the circumstances of trade demanded it the metre-gauge lines might be allowed access to the ports of Bombay, Calcutta and Karachi. The metre-gauge lines in Eastern and Northern Bengal were separated from the broad-gauge lines by a defined boundary, the Ganges and Brahmaputra rivers, and when the Northern Bengal and Tirhut railways were made in 1870–75 this obstacle was an insuperable one. Now, however, there was a probability that a bridge would shortly be built at Sara, and if this were done these two gauges would be connected. A proposal in which he was interested had recently been submitted to the Bengal Chamber of Mr. Molesworth.

Mr. Molesworth. Commerce for bringing the metre gauge into Calcutta by bridging the Ganges at Sara, and constructing a metre-gauge line crossing the Eastern Bengal railway at or near Halsha, running through a densely-populated and fertile country by Jhanidah and Naldanga to Jingergatchi on the Bengal Central railway, which railway would be converted to the metre gauge, and, if necessary, doubled. The scheme also proposed a metre-gauge line from Nowapara on the Bengal Central railway to Paterdi on the Torki River, and a steam-ferry to convey metre-gauge rolling stock between Narainganj on the Dacca and Maimansinh railway, Chandpur on the Assam-Bengal railway, and Paterdi. There need be no fear as to the conversion of the Bengal Central railway to the metre gauge; the traffic on this line had never been remunerative, as it had never seriously competed with the communication by water. The disposal of the metre-gauge rolling stock at Calcutta presented great difficulties, owing to the complexity of the Port Commissioners' sidings. The third rail was probably inadmissible; transfer-trucks might be used, or the overhead transporters suggested by the Author; but the development of Calcutta as a first-class port would probably lead at no very remote date to the canalization of the Mutla River, when access to the docks on the metre-gauge could be arranged. The cost of the new works would be approximately £1,750,000; the capital cost of the Bengal Central railway was approximately £1,000,000 more. This proposal presented a simple and practical method of minimizing the disadvantages of the present break of gauge in one province, and was not so costly as to preclude a fair return on the capital expended.

Mr. Preston. Mr. SIDNEY PRESTON thought that reference might usefully have been made in the Paper to the further complication of the problem of the railway-gauges of India by the introduction of the 2-foot 6-inch and 2-foot gauges. The latter might perhaps be ignored, as at the close of 1903 there were only 262 miles open and 113 more under construction or sanctioned; at the same time it was a matter for regret that there should be two gauges which differed by so little as 6 inches. The 2-foot 6-inch gauge, of which at the close of 1903 there were 796 miles open and 575 miles under construction or sanctioned, could not, however, be ignored. It would have been useful if the Paper had contained a statement showing where the lines of this gauge were situated. So long as they were confined to lines in the hills, such as the Kalka-Simla, or Darjiling railways, exception could probably not be taken to them, as such lines must necessarily be feeders to main lines in the plains. But the case of lines in the plains was on a different footing, and it was a pity that

a third gauge had been introduced to further complicate the already sufficiently difficult problem. For instance, the North-Western railway at Saharanpur and the East Indian railway at Shahdara were standard-gauge lines. Was it not a pity that they should be connected by a 2-foot 6-inch gauge line? Further, Shahdara was only 8 to 10 miles from the great junction of Delhi. Now it was not unreasonable to think that in the near future the Saharanpur-Shahdara line would, if the traffic developed as was anticipated, claim to enter Delhi, so as to transfer its traffic direct into the metre-gauge wagons of the Rajputana railway system. Should this be conceded there would, at some future date, be the complication of three gauges entering Delhi; or, if it were not conceded, the traffic from the Saharanpur-Shahdara line for the metre-gauge system, would be subjected to two changes of bulk in a distance of 8 to 10 miles. Neither of these alternatives could be viewed with equanimity. The disadvantages were so obvious that it would be interesting to know the reasons which had influenced the Government in sanctioning a 2-foot 6-inch gauge for the Saharanpur-Shahdara line. Mr. Preston understood that it was due to the fact that it was to be constructed under the Tramways Act, and not under the Railway Act. He was not sufficiently conversant with the details of these two Acts to say anything regarding them, but he believed that one of the advantages of the former was that local governments could sanction lines as "tramways," while railways must be included in the programme of the Government of India, and be sanctioned by them. This necessarily caused delay, and the sanction was not so easily obtained. The construction of the Saharanpur-Shahdara line as a tramway might therefore be satisfactory from the promoter's point of view, but it was questionable whether it was wise of the Government to invent or authorize a system which, as far as could be seen, must still further complicate the question of the railway-gauges of India. Whether there were other lines similarly situated Mr. Preston was unable to say, and for this reason he regretted the absence of a Table for the 2-foot 6-inch gauge, similar to Tables I and II for the standard and metre gauges. If there were other similar lines, either existing or contemplated, it only emphasized the objection to a third gauge. He could not but think that the Saharanpur-Shahdara line should be built on either the standard or the metre gauge. The former would be the same as the gauge of the two lines it would connect, while the latter would allow of the line being connected with the Rajputana system if necessary. Having no personal interest in any of the railways referred to he merely offered these remarks in the interests of the general railway-system of India.

Mr. Presto

Mr. Robertson. Mr. F. E. ROBERTSON observed that most discussions on gauge question had been vitiated by the implicit assumption all the dimensions were geometrically similar, and by the omi to remember that speed was a commodity which was somet worth money. When it was considered that some narrow-g lines possessed heavier rolling stock than lines of considerably v gauge, and that generally the body-width bore no fixed ratio to gauge, it would be seen that the actual distance apart of the was, within limits, scarcely worthy of serious discussion. Prob if the railway world could begin again, a normal gauge of 5 feet a narrow gauge of 2 feet 6 inches would be chosen, and these with the great variations in cost and carrying-capacity which act existed on the same gauge, would fully meet all requirements. at least of the alternatives suggested in the Paper, namely, alter of both the broad gauge and the metre gauge to the English gauge in Mr. Robertson's opinion, nothing to recommend it. The run dimensions of the broad gauge would remain unaltered, and it difficult to see what would be gained by putting the rails a inches nearer together, either on existing lines or on those t built. Nor could there be any serious discussion of the abolitic either the broad or the metre gauge as an ultimate object. It n perhaps be regretted that a 2-foot 6-inch gauge had not been chose local lines, but the metre gauge had undoubtedly come to stay, the decision in any particular case whether to double or to wic metre-gauge line which had attained its limit must depend upon circumstances; the question was not susceptible of any general an One of the first considerations would naturally be the prospect o construction of other lines which might take off any surplus of t by direct communication with the terminus, or which, if bui branches, would still further increase the flow of traffic on the route. One argument in favour of pushing back the point of jun up the metre gauge was the speed question. The longer the lin the heavier the traffic, the more was speed required, and the b could it be afforded; but even here a direct answer was difficult t For the comparison would be between a single broad-gauge and a d metre-gauge track, and the superior speed of the former in a running might be seriously handicapped by the delays inevitab single-line working. The difference in running-speeds between two gauges was not really known, for the broad-gauge was in respect usually worked in such a leisurely way that the metre g had no difficulty in keeping fairly close to it. As to the minor ga the difference was so small as to mean nothing, and the 2-foot 6 gauge should prevail, simply because there was more of it.

Mr. E. I. Shadbolt remarked that, having regard to the Author's general conclusion that a line of 5-foot 6-inch-gauge had double the capacity of a metre-gauge line, and that a double line of either gauge had five times the capacity of a single line, no further arguments were required to show that, if a single gauge were adopted as the standard for India, it should not be the metre gauge. In reviewing the three possible methods of attaining uniformity of gauge, it was assumed in the Paper that the ultimate limit of capacity was proportional to the gauge when that limit was reached. This was not quite correct. The ultimate capacity for goods-traffic, at least, was rather proportional to the dimensions of the loading-gauge—or what were known in India as the "standard moving dimensions"—combined with speed. A glance at Figs. 8, Plate 2, showed that these dimensions, as adopted in India, were by no means proportional to the gauge. In the one case there was an outside width of 10 feet 6 inches on a gauge of 5 feet 6 inches, while in the other there was a width of 8 feet 6 inches on a gauge of 3 feet $3\frac{3}{8}$ inches. The size of the loading-gauge was relatively much larger on metre-gauge lines than on 5-foot 6-inch lines; and while this was an advantage so long as low speeds were maintained, it was fairly well agreed among engineers in India that any appreciable increase of speeds on the metre gauge was impracticable, as stability would be endangered thereby. While, therefore, the speeds of metre-gauge trains shown in Table IV would never be greatly exceeded in practice, those of 5-foot 6-inch lines, shown in the same Table, did not nearly approach the limits that might be attained if circumstances should render it worth while. From the experience of England, America, and most of the countries of Europe, with railways of the 4-foot $8\frac{1}{2}$-inch gauge, it was fairly well known what those limits were. The speeds conveniently attainable were certainly more than double those shown in the Table, and if only double those speeds were adopted in India, the carrying-capacity of the 5-foot 6-inch lines would work out to four times that of the metre-gauge lines; while, so far as passengers were concerned, the facilities and conveniences afforded would be more than double those of metre-gauge lines. In the foregoing remarks the conditions which obtained with regard to the English gauge were assumed to be practically identical with those of the Indian 5-foot 6-inch gauge. This was really the case, for, as already indicated, capacity was proportional to the loading-gauge adopted, and not directly to the gauge of the rails. The loading-gauge for the 5-foot 6-inch gauge was practically that of English railways, and somewhat smaller than on American railways. When railways

Mr. Shadb

pp. 9. 10. 12.

Mr. Shadbolt. were first introduced into India, the English practice was followed with little variation, the only difference being in the greater width apart of the wheels. This modification was considered necessary owing to a fanciful apprehension of the effects of high winds upon the stability of vehicles. Having once been adopted, the loading-gauge was limited by the fixed dimensions of tunnels, bridges, and other structures. Neither could be modified to any considerable extent. It might be accepted, therefore, that all the advantages possessed by the 5-foot 6-inch gauge, as compared with the metre gauge, were equally possessed by the 4-foot 8½-inch gauge so far as related to actual carrying-capacity. But the English gauge had further advantages, in that it allowed of the construction of a better and more economically proportioned vehicle, with shorter axles for the same body. It also admitted of more flexibility in laying out a railway, as sharper curves could be employed. Above all, it had been adopted by all the leading commercial countries of the world, and the full sum of their great experience in design and working was thus at the disposal of those who were wise enough to follow in their steps. The Paper truly intimated that it was not necessary, in this Institution, to demonstrate the advantages of uniformity of gauge, and all the arguments that were set forth in favour of uniformity in one country applied, though in varying degrees, to uniformity in many countries. The advantages of general standardization in engineering matters had been much discussed, and were now fully accepted. Such as they were, they existed equally in the case of the standardization of railway-gauges. England had shown its adhesion to this principle by the conversion of one of its two gauges, and America by the conversion of the dozen or so of various gauges that existed prior to 1885. The conclusion might be accepted with absolute confidence that there should be one gauge in India, and that this gauge should be the gauge of 4 feet 8½ inches adopted in England, in America, on the continent of Europe, and in other countries. The reference in the Paper to questions of cost and difficulty of conversion applied only to the 25,000 miles of railway existing in India, and practically took no heed of the developments that must necessarily occur in the future. It was said that India had not now a clean slate to start on. No doubt a precisely similar remark would have been made 20 years ago when there were 11,000 miles of railway, or 30 years ago when there were only 6,000 miles. But everything seemed to indicate that the railways of India would be steadily added to until the whole country was covered with a network of lines perhaps 50 miles apart, perhaps even 25 miles apart. The progress would certainly not be checked until 100,000 miles

Mr. Shadbolt. or more had been constructed: the development would be continuous, and this mileage might be completed in a period of 50 or 60 years. Relatively speaking, therefore, India *had* a clean slate, because the existing mileage was insignificant in comparison with the mileage that would ultimately be attained, and ought now to be considered. It must be remembered that the disadvantages of break of gauge had hitherto been scarcely felt. Where traffic had been on a moderate scale, the mere cost of transhipping goods had been found to be equivalent to about 20 miles of haulage. But if the two gauges were ever brought together into seaport towns, or into coal-fields or other large centres of traffic, the expense, the difficulties, and the confusion, would be multiplied a hundred-fold. Experience had shown that the administrations of lines of different gauges did and would press for equal rights and facilities in such cases, not in any way to the benefit of the country, but merely for the sake of securing a favourable position with regard to competition. It was difficult for the Government to resist such demands, although in the great majority of cases the work had to be carried out at the expense of the tax-payer, for unassisted private enterprise in India was practically non-existent. About four-fifths of the railways were owned by the State, and the small working-capital provided by companies, to whom the working of many of the lines had been entrusted, was furnished by them under a guarantee of interest. In such cases the private enterprise did not differ essentially in character from the enterprise of depositing money in the Post Office Savings Bank. Clearly it was the future and not the present that should be taken into consideration. If action were delayed, it might well be that a future generation would look back with amazement at the timidity which led to the evasion of the problem at a time when only 25,000 miles of road had to be dealt with. The cost of converting a metre-gauge road to the 5-foot 6-inch gauge was shown in the Paper to be Rs.38,750 to Rs.43,000 per mile. In both the cases quoted, about half the expense was due to the substitution, for the light permanent way of the metre-gauge line, of the heavier permanent way necessary for the increased traffic expected on the 5-foot 6-inch gauge. But there were many railways in India which had been constructed for administrative reasons or with a view to protection from famine, and on which the traffic was very light. On such lines there was no reason why the light metre-gauge rails should not be retained for the wider gauge—at least for a time—and the expense of heavier rails be avoided. Perhaps it was fair to assume that the conversion of one-half of the metre-gauge lines in India would cost Rs.40,000 per mile, and that of the other half

Mr. Shadbolt. less than Rs.30,000 per mile. It must not be forgotten that on metre-gauge lines where traffic was increasing, considerable expenditure would be necessary for increasing the strength of rails, girders, and other works, whether conversion took place or not. There was no record of the cost of converting a 5-foot 6-inch line to a gauge of 4 feet 8½ inches, but where traffic was small it would be trifling. On a busy line a temporary mixed gauge might be necessary to avoid a stoppage of traffic, and the cost would then be higher; but the same materials would be used, and there would be no outlay for stronger rails or girders. There had been one or two instances in which a 5-foot 6-inch line had been converted to the metre gauge. This operation had been performed on a section of railway not far from Karachi, extending from Haidarabad Sind to Shadipalli, a distance of 50 miles. It was a cheap line, laid with flat-footed rails on wooden sleepers, and having a few openings spanned by plate girders carrying wooden transverse sleepers. The conversion had involved little more than moving in one rail to a new position on the sleeper. It had been carried out by the ordinary maintenance-gangs at the rate of a station-to-station length of 8 to 10 miles daily, the trains of the two gauges meeting end-on at a station, and passengers moving from one to the other. The total cost had not exceeded a few hundred rupees per mile, and the engineer-in-charge had asserted that the value of the ends sawn off the long sleepers had paid for the whole operation. The conversion of a 5-foot 6-inch to a 4-foot 8½-inch road would present even fewer difficulties, and on wooden-sleeper roads generally the cost
66⅔ might be taken at not more than Rs.1,000 per mile. Many roads in India, however, were laid with cast-iron sleepers connected by tie-rods, or with pressed-steel sleepers. In such cases the cost of con-
333⅓ version might amount to Rs.5,000 per mile. On busy lines, where a temporary mixed gauge would be required, the ultimate cost might come to Rs.20,000 per mile. With regard to rolling stock, if the conversion were spread over a term of years, the present rolling stock could be largely used on lines of existing gauges during the transition period. By the time conversion was complete, much of the stock would be worn out, and only the remainder would have to be dealt with. There would be some expense, but the item would not be a serious one. Reference was made in the Paper to the "confusion" which would accompany conversion; but a difficult operation was not necessarily attended by confusion. Whether an operation was simple or complex, it was only necessary that arrangements should be made to suit the circumstances. The large body of experienced railway-engineers in India would be quite equal to doing

whatever might be required, without causing any confusion or appreciable dislocation of traffic. The rate of conversion would become merely a question of cost, and would depend on the circumstances of each case. A line could be converted in a Saturday-to-Monday interval if it were worth while to complete the operation in so short a period. To sum up, the conclusions Mr. Shadbolt arrived at were:—That a uniform gauge should be adopted for India; that this should be the 4-foot 8½-inch gauge; that not another mile of any other gauge should be laid, but that all lines now under construction should be completed to the new standard gauge; that conversion of existing gauges should be begun on State-worked lines; that in new contracts with working companies whose existing contracts would shortly expire, provision should be made for conversion. Probably it would not be practicable to force conversion on companies having contracts with some years to run; but if the steps indicated above were taken, most of them would probably be prepared to come into line in their own interests. So far as they refused to do so, the worst that could happen would be that conversion might possibly be delayed till the termination of their current contracts. Mr. Shadbo

Mr. F. J. E. Spring considered that the Paper confirmed the opinion at which he had long ago arrived, that it would be folly to attempt now to bring about uniformity of railway-gauge in India. The abolition of the numerous existing breaks of gauge would doubtless serve to oil the wheels of trade to some appreciable extent. But practical administration could not hearken to counsels of perfection which—however useful they might have been 30 or 35 years ago—were now quite outside the scope of action. The theory that break of gauge was an intolerable evil had originated with the military advisers of Government on the north-west frontier, where considerations of facility for transporting troops and war-materials must necessarily outweigh all other considerations, and where it was so important that in time of war there should not be a break of gauge that it was considered worth while to keep hundreds of miles of railway, even during years of peace, doing perhaps only one-half or one-quarter of the work which they were capable of doing, and no more than might perfectly well be done by a railway of narrower gauge costing only half the money. But these considerations, which so influenced the northern railway-administrations, did not altogether apply to other lines. It was often forgotten that most of the evils of break of gauge were going on daily and hourly in scores of places all over India, without traders being conscious of them, or any attention being paid Mr. Spring

Mr. Spring. to them: he referred to the unloading of foreign wagons, in order that they might be returned, when they arrived too lightly loaded on lines other than their own. The Author gave 5½d. per ton as the cost of transhipment, or the equivalent of about 20 miles of haulage, but Mr. Spring had evidence of its costing much less than this. When in charge of the Madras Government Railway Department a few years ago, he had found it necessary to tender advice to district boards (county councils) in that Presidency, which, as the result of certain new legislation, had had to consider the question of light local railways. On the subject of transhipment he then wrote—

"From evidence supplied to me by four traffic experts, all working in Southern India, it would appear that from 1 to 1½ annas (pence) per ton is a fair price for transhipping from one gauge to another, while it may run up to 3½ annas (pence) for specially bulky and troublesome goods, and may cost, for such goods as grain, as little as half an anna per ton. . . . . On the Morvi Railway the average sum received in ten half-years for the carriage of *one ton* of goods *one mile* was about 1¼ anna, or a penny-farthing.

"A not unimportant item of cost of transhipment consists of payments by the railway administration of claims made by consignors or consignees on account of damage occasioned to goods by being handled. But the public soon get to recognize that, when their goods are carried by carts or by canal boat, there is practically no possibility of recovering anything on account of damage done in transit; while in dealing with railways such recoveries are made in the ordinary course of business.

"As an ordinary charge for railway freight of average goods is from 3 to 6 pies (one farthing to one halfpenny) per ton-mile, and as the cost of transhipment is from 1 to 1½ annas (a penny to three halfpence) per ton, it follows that the cost of transhipment is equivalent, according to class of goods handled, to haulage over from three to six miles of railway. This cost the merchant of course pays, but he pays it indirectly, for the general run of rates throughout a railway system is regulated by the management so as to cover *all* incidental charges, of which transhipment is one. It may safely be predicated that the cost and delay of transhipment at the junction of a railed road with the main line of which it is a feeder, when added to railway freight charges, will usually be considerably better for the consignor than the cost and delay incidental to carriage by country cart."

The managers of Indian railways—whether State or companies' lines—naturally and rightly looked upon certain territories and cities as peculiarly their own scene of action for earning-purposes, and they resented seriously the advent of rival companies athwart or into their territory. Indeed, the battle of the gauges in India had become for the most part a battle between the traffic-managers of rival railways of different gauges. The 5-foot 6-inch gauge, being for the most part the older line in a given territory, and its management having in the past been at times somewhat conservative, not to say hidebound, in the matter of branches and extensions, it had naturally followed that here and there the cheaper and more modern metre-gauge had

pushed its way gradually into the territory of its older and less vigilant neighbour, often right into centres of trade, *e.g.*, Bangalore, Cawnpore, Lucknow, etc., which the broad-gauge lines had got into the habit of counting as their peculiar trading-territory. Hence much of the acrimony which characterized the rivalry between the two gauges. Such rivalry was seldom exhibited between lines of similar gauge—at least, not in so acrimonious a form. Such a spirit, though right and proper between the partisans of the several gauges, would be totally out of place if exhibited by the advisers of Government, who were, or ought to be, and ought to consider themselves as being, the trustees of a voiceless mass of tax-payers whose interests were the sole or the chief interests to be taken into account, directly and indirectly. What the Indian tax-payer wanted, and what he would ask for were he only articulate, was railways, and more railways, so long as he could earn from them at least as much—say 4 per cent.—as, all told, the money cost him which directly or indirectly he spent on them. He wanted a means of transport which would carry his field-produce to market 80 miles in a night instead of 8 miles, and at not much greater expense for the 80 miles than for the 8 miles. The town merchant wanted to find the villages of India—parishes they would be called in England, only with the houses grouped instead of scattered—within a 10-mile walk, or even a 20-mile tramp, of a railway-station—a state of things which as yet was far from being the case. He wanted to buy and carry off the villager's field-produce, and to give him in exchange the things he could not grow but which were produced by other parts of India or even by foreign countries. All concerned wanted to be able to get about more easily and quickly, for they were keen travellers when they could afford it. But they did not care so much about speed, for, compared with the 2 miles per hour of the paternal bullock-cart that had served them for untold generations, the 15 or 20 miles per hour of a metre-gauge or even 2-foot 6-inch railway was a giddy whirl to be talked of for long after it was first experienced. Also, they liked to get out and loiter at the stations, and they felt that they were being cheated of half the joys of the journey if whisked off again before their smoke and general wash-up were finished. Had these people a voice—and it should always be remembered that they owned the railways—that would say: "Give us 200 miles instead of 100 and 2,000 instead of 1,000, if it can be done at the same cost; but don't trouble to give us European speeds and luxuries of travel, for we don't value them." The town merchant did not want to be able to trade only with Agra, Jhansi and Allahabad, or only with Madras and Calicut; he wanted also to trade with Ajmere and

Mr. Spring.

Mr. Spring. Gorakhpur, or with Marmagao and Masulipatam. He knew nothing about gauge, but he wanted to feel that as many routes as possible had termini in his town, so that his goods might go through without complication. These were the things that a wise trustee, who was not a mere railway partisan, would try to give the people of India— more railways, the maximum mileage for the available money consistently with suitability for the probable traffic, and the freest access of all neighbouring railways, or failing that, of both the main gauges, into the chief centres of trade. As compared with all this, the inconvenience to India of mere break of gauge was the veriest trifle, and insistence on the extension of the standard gauge without reference to local conditions indicated, to Mr. Spring's mind, a lack of the wisdom which might be looked for in a statesman. The Paper brought out certain facts which it seemed desirable, in the interests of clearness, to recapitulate. These were:—

(1) The mileage of the 5-foot 6-inch or Indian standard gauge was only about 15 per cent. in excess of that of the metre and other gauges.

(2) It cost about twice as much to build a 5-foot 6-inch line as to build a metre-gauge line. Yet in India both gave about the same return on the capital expended, the chief reason for this being that the broader gauge had been first in the field in the richer countries.

(3) The general capacity of the 5-foot 6-inch gauge was about double that of the metre gauge.

(4) For rough purposes it might be accepted that it would cost about £2,500 per mile to convert a line of metre gauge to the 5-foot 6-inch gauge, including rolling stock.

(5) It would apparently cost about £3,400 per mile to double a piece of metre-gauge line, including rolling stock.

(6) Transhipment from one gauge to the other appeared to cost about $5\frac{1}{2}d.$ per ton, or the equivalent of about 20 miles of haulage. This, however, Mr. Spring believed to be over-estimated for most parts of India.

(7) When a metre-gauge line was found to be overworked, the expenditure on it of £2,500 per mile for its conversion to the 5-foot 6-inch gauge would about double its carrying-capacity; but the expenditure on it of about £3,400 per mile for doubling it without altering its gauge would quadruple its capacity. In view of these figures and of the facts and arguments put forward in the Paper, and in the light of over 30 years of close connection with most parts of the Indian railway-system, during a period in which that system was expanding from about 5,000 to about 30,000 miles, he thoroughly endorsed the conclusion at which Mr. Upcott had arrived, namely

that: "For many years to come India needs all the money she can get for fresh lines, and will have little or nothing to spare for adopting a counsel of perfection. India has not now a clean slate to start on, and she must needs by compromise make the best of each case as it arises." Mr. Spring

Mr. C. F. SYKES considered that the experience and example of all the great countries of the world put the question whether there should be a uniform gauge for railways throughout India practically beyond discussion; and that the question for consideration brought out in the Paper was really confined to the merits or demerits of the existing gauges, particularly as compared with each other, on the assumption that the practical method of obtaining uniformity was by the conversion of either gauge to the other. All comparisons hitherto made between the capabilities of metre-gauge and standard-gauge lines appeared to be based on the initial cost and cost of working of single-track "pioneer" lines. Relative to the standard-gauge lines in India, metre-gauge railways were essentially light railways. The maximum axle-loads were about one-half of those obtaining on the standard gauge, the relative weight of rails being about two-thirds. It might be laid down as a principle that, for traffic within the limits of its capacity, any single-track light railway would compare favourably, in first cost and cost of working, with a railway built to a heavier standard; and that traffic beyond that limit would never be dealt with by duplication and reduplication of light lines, but by concentrating loads on single tracks to the utmost they would bear, the single track of the greatest load-capacity combined with the greatest speed being the most efficient—whatever the gauge might be. The true criterion in this case, therefore, was not the merits of the two gauges for pioneer lines (a light line could be constructed equally well on the standard gauge), but the capability of dealing with the maximum gross traffic ultimately to be developed. It was not too optimistic to assume that, if the railways were retained on the standard gauge, all the trunk-lines would be doubled within the next decade, or two decades, and would be quadrupled on the sections leading into the seaports. In fact the necessity for quadrupling had already arisen in some instances. Any claim to make the metre gauge universal must therefore be based on its capability to deal with the traffic which this implied. From the data in the Paper it seemed fair to assume, for this purpose, that the gross carrying-capacity of a single standard-gauge track was equivalent to that of a double-track metre-gauge railway, and it would be necessary, therefore, to substitute a four-track metre-gauge railway for each double standard-gauge railway, and six Mr. Sykes.

Mr. Sykes. or ultimately eight metre-gauge tracks for a quadruple stand gauge railway. The relative cost on this basis could not be prop estimated from the cost of existing lines, which, as noted in Paper, had been constructed at different periods over half a cent and under widely varying conditions; but it might easily be seen comparing the works under the following different heads:—

Formation.—The relative widths of formation would be—

	Feet.	Inches
Standard-gauge single-track	20	0
Metre-gauge double-track	28	6
Standard-gauge double-track	34	0
Metre-gauge quadruple-track	53	6
Standard-gauge quadruple-track	62	0
Metre-gauge sextuple-track	78	0
„ „ octuple-track	103	0

Tunnels.—A double-track metre-gauge tunnel 30 feet wide w be required in place of a single-track tunnel 17 feet wide on standard gauge, or two such tunnels for each double-track stand gauge tunnel.

Bridges.—The cost of barrels of culverts and of piers and abutm of girder-bridges, apart from the wings, would be increased in portion to the width of formation. For small girder spans up t feet two pairs of girders would be required for each pier on standard gauge, with an increase of about 50 per cent. in cost. large bridges the comparison would be the same as for tunnels.

Permanent Way.—The following was a comparison bet the weights of the rails in use on the two gauges:—

	Metre-Gauge.	Standard-Gauge.
Light lines	41 lbs. per yard.	62 lbs. per yard.
Ordinary standard	50 „ „	75 „ „
Heavy „	60 „ „	90 „ „

That was to say, the gross weight of rails on a double-track m gauge railway would be 33 per cent. greater than the equivalent si track standard-gauge line. The cost of sleepers would be about same, but on the metre-gauge line they would require abou per cent. more ballast than on the standard-gauge line.

Signals, etc.—The cost of signals, etc., would be much the sam either a single- or a double-track railway, but as between a do track and a four-track railway the cost would be doubled, and cost of interlocking probably more than doubled.

Stations, etc.—In large goods-yards, assuming that accommoda had to be provided for the same gross bulk of goods standing in wa at one time, three metre-gauge tracks occupying a width of 36

would be required in place of two standard-gauge tracks occupying a width of 27 feet. The cost of land and maintenance-charges would also be increased in proportion. Mr. Sykes.

These facts formed the basis of the principle first laid down. Other considerations, such as speed and general convenience and the comfort of the travelling public, were still more adverse to the metre gauge. Journeys in India on the standard gauge extended to 2,000 miles or even more, the time taken being 2 to 3 days for a single journey without a break. Substituting the metre gauge would mean a reduction of about 30 per cent. in the average speed, or an increase of about 50 per cent. in the time occupied. For long journeys, existing metre-gauge routes were shunned, wherever practicable. Mails and passengers from Bombay for the Punjab made the detour by Jhansi and Agra, and similarly mails and passengers from the west for Northern Bengal and Assam proceeded via Calcutta. In the face of these considerations, the idea of uniformity throughout India on the metre gauge was hardly conceivable. A principal factor which had brought the metre-gauge systems into being was the practical prohibition of the construction of light railways on the standard gauge. Assuming the ordinary metre-gauge standard of construction, with 50-lb. rails and corresponding weights of locomotives, the factors governing the difference in cost of construction of a light railway on the 5-foot 6-inch gauge to the same standard of construction were:—(1) The formation-width would be increased by 2 feet; (2) The cost of sleepers would be increased by about £200 per mile. Against this would be a saving on transhipping-arrangements, and on rolling stock; for such a line would be able to carry the ordinary four-wheeled coaching- and goods-stock of the standard gauge at low speeds. No light line of this kind existed, nor, as standards were fixed at present, was permitted to exist; and all comparisons of cost between metre-gauge and standard-gauge lines or feeders had been made hitherto, not as between lines constructed up to the same standard of construction or carrying-capacity on each gauge, but on the basis that a railway of 5-foot 6-inch gauge must necessarily be constructed to a much heavier standard. In India, a light railway and a narrow-gauge railway had come to be synonymous terms; and this had brought about the introduction of yet another gauge—the 2-foot 6-inch gauge—in situations where a light railway on the same gauge as the main line would be preferable and ultimately more economical. The cost of conversion of such a light line would, on the whole, be nearly the same as the conversion of a narrow-gauge railway, with the important exception that the rolling stock would not be scrapped. The conversion, however, would

Mr. Sykes. or ultimately eight metre-gauge tracks for a quadruple standard-gauge railway. The relative cost on this basis could not be properly estimated from the cost of existing lines, which, as noted in the Paper, had been constructed at different periods over half a century, and under widely varying conditions; but it might easily be seen by comparing the works under the following different heads:—

Formation.—The relative widths of formation would be—

	Feet.	Inches.
Standard-gauge single-track	20	0
Metre-gauge double-track	28	6
Standard-gauge double-track	34	0
Metre-gauge quadruple-track	53	6
Standard-gauge quadruple-track	62	0
Metre-gauge sextuple-track	78	0
„ „ octuple-track	103	0

Tunnels.—A double-track metre-gauge tunnel 30 feet wide would be required in place of a single-track tunnel 17 feet wide on the standard gauge, or two such tunnels for each double-track standard-gauge tunnel.

Bridges.—The cost of barrels of culverts and of piers and abutments of girder-bridges, apart from the wings, would be increased in proportion to the width of formation. For small girder spans up to 60 feet two pairs of girders would be required for each pier on the standard gauge, with an increase of about 50 per cent. in cost. For large bridges the comparison would be the same as for tunnels.

Permanent Way.—The following was a comparison between the weights of the rails in use on the two gauges:—

	Metre-Gauge.	Standard-Gauge.
Light lines	41 lbs. per yard.	62 lbs. per yard.
Ordinary standard	50 „ „	75 „ „
Heavy „	60 „ „	90 „ „

That was to say, the gross weight of rails on a double-track metre-gauge railway would be 33 per cent. greater than the equivalent single-track standard-gauge line. The cost of sleepers would be about the same, but on the metre-gauge line they would require about 50 per cent. more ballast than on the standard-gauge line.

Signals, etc.—The cost of signals, etc., would be much the same for either a single- or a double-track railway, but as between a double-track and a four-track railway the cost would be doubled, and the cost of interlocking probably more than doubled.

Stations, etc.—In large goods-yards, assuming that accommodation had to be provided for the same gross bulk of goods standing in wagons at one time, three metre-gauge tracks occupying a width of 36 feet

would be required in place of two standard-gauge tracks occupying a width of 27 feet. The cost of land and maintenance-charges would also be increased in proportion. Mr. Sykes.

These facts formed the basis of the principle first laid down. Other considerations, such as speed and general convenience and the comfort of the travelling public, were still more adverse to the metre gauge. Journeys in India on the standard gauge extended to 2,000 miles or even more, the time taken being 2 to 3 days for a single journey without a break. Substituting the metre gauge would mean a reduction of about 30 per cent. in the average speed, or an increase of about 50 per cent. in the time occupied. For long journeys, existing metre-gauge routes were shunned, wherever practicable. Mails and passengers from Bombay for the Punjab made the detour by Jhansi and Agra, and similarly mails and passengers from the west for Northern Bengal and Assam proceeded via Calcutta. In the face of these considerations, the idea of uniformity throughout India on the metre gauge was hardly conceivable. A principal factor which had brought the metre-gauge systems into being was the practical prohibition of the construction of light railways on the standard gauge. Assuming the ordinary metre-gauge standard of construction, with 50-lb. rails and corresponding weights of locomotives, the factors governing the difference in cost of construction of a light railway on the 5-foot 6-inch gauge to the same standard of construction were:—(1) The formation-width would be increased by 2 feet; (2) The cost of sleepers would be increased by about £200 per mile. Against this would be a saving on transhipping-arrangements, and on rolling stock; for such a line would be able to carry the ordinary four-wheeled coaching- and goods-stock of the standard gauge at low speeds. No light line of this kind existed, nor, as standards were fixed at present, was permitted to exist; and all comparisons of cost between metre-gauge and standard-gauge lines or feeders had been made hitherto, not as between lines constructed up to the same standard of construction or carrying-capacity on each gauge, but on the basis that a railway of 5-foot 6-inch gauge must necessarily be constructed to a much heavier standard. In India, a light railway and a narrow-gauge railway had come to be synonymous terms; and this had brought about the introduction of yet another gauge—the 2-foot 6-inch gauge—in situations where a light railway on the same gauge as the main line would be preferable and ultimately more economical. The cost of conversion of such a light line would, on the whole, be nearly the same as the conversion of a narrow-gauge railway, with the important exception that the rolling stock would not be scrapped. The conversion, however, would

This represented 75 per cent. on the original cost of the single line (£4,700), and might be regarded as a fair approximate proportion for general application. It would be observed that the rate per mile corresponded very closely with that in the estimate for doubling given in the Paper; but apparently the rate for land taken therein was an error and should be reduced by at least £400, making the Author's estimate £2,930. The following ratios of cost were therefore obtained as data to work from in cases in which conditions were in all respects similar:— Mr. Thoms

(1) First construction of metre-gauge to first construction of standard-gauge, 1 to 1·33.

(2) Metre-gauge to same converted to standard-gauge, 1 to 1·55.

(3) Metre-gauge to doubled metre-gauge, 1 to 1·75.

If, as he believed, these data were fairly accurate, it would seem at first sight that there could be little or no justification for the adoption by the Government of India of the metre gauge to anything like the extent to which it had been adopted. In order to judge the question fairly, however, it must be considered from the point of view of the proprietor (in this case the Government of India), whose first consideration, apart from political or military necessities, must be: "Which will pay best?" This could best be answered by comparing the financial results of a line of each gauge on the same "location," their relative cost being known; and if the latter were taken as 1 to 1·33 it would certainly not be placing the standard gauge at a disadvantage in making the comparison. In working out such a case the results would be found to be largely in favour of the metre gauge; so much so as probably to surprise anyone who had not made the comparison before. In order to show the results in a convenient form the Table on p. 124 had been prepared as an example, exhibiting the comparative results progressively in 3-year periods for 30 years; and, although a hypothetical case, the results would apply, *ceteris paribus*, in all similar cases, in so far as they represented the proportionate advantage of the metre gauge over the standard gauge as a commercial investment. For this Table the gross earnings were assumed as beginning at £420 per mile per annum, rising to £840 per mile; the working-expenses at 50 per cent.; the capital borrowed by the Government at 3½ per cent.; and the loss or surplus profits (as the case might be), after payment of interest on borrowed capital, accumulated at 3½ per cent. com-[illegible] interest. The results for the metre gauge shown in the [illegible] they were, were no better than, if equal to, the [illegible] by one of the existing metre-gauge lines (the [illegible] on which the gross receipts for the year 1898,

. Thomson.

Periods (Three-Yearly).	Metre-Gauge Railway, costing £6,000 per Mile.			Standard-Gauge Railway, costing £8,000 per Mile (a Ratio of 1·33 to 1 as compared with the Metre-Gauge).		
	Net Earnings per Mile (50 per Cent. of Gross Earnings).	Loss (–), or Surplus Profits (+), per Mile of Line after paying Interest at 3½ per Cent. on Capital Cost.		Net Earnings per Mile (50 per Cent. of Gross Earnings).	Loss (–), or Surplus Profits (+), per Mile of Line after paying Interest at 3½ per Cent. on Capital Cost.	
		Per Annum.	Accumulated at 3½ per Cent. Compound Interest.		Per Annum.	Accumulated at 3½ per Cent. Compound Interest.
	£	£	£	£	£	£
1—3	210	Nil	Nil	210	– 70	– 217
4—6	240	+ 30	+ 93	240	– 40	– 365
7—9	270	+ 60	+ 290	270	– 10	– 435
10—12	300	+ 90	+ 600	300	+ 20	– 420
13—15	330	+120	+1,039	330	+ 50	– 311
16—18	360	+150	+1,618	360	+ 80	– 96
19—21	390	+180	+2,352	390	+110	+ 235
22—24	390	+180	+3,166	390	+110	+ 601
25—27	420	+210	+4,161	420	+140	+1,100
28—30	420	+210	+5,264	420	+140	+1,655

NOTE.—With the assumed traffic the metre-gauge line would be able, out of surplus profits, in 24 years to pay for conversion to standard gauge or in 28 years to pay for doubling.

17 years after opening for through traffic, were £836 per mile. In view, therefore, of the undoubted advantages, as commercial undertakings, of metre-gauge over standard-gauge railways, in a great many cases in India, it seemed that the only conclusion that could be arrived at was, that each case should be dealt with on its merits, bearing in mind that, from a financial point of view, there could be no justification for constructing a railway on the standard in preference to the metre gauge, unless a reasonable prospect existed that within a moderate period the traffic would be beyond the capacity of a metre-gauge line, or that, as an extension or connection of existing standard-gauge lines, or for military or other State reasons, the adoption of the broader gauge was imperative.

Mr. Wolley-Dod.

Mr. F. WOLLEY-DOD remarked that as the primary object of the Paper was to obtain opinions as to the best policy to adopt in the immediate future in order to abate the evil of two principal gauges in India, it seemed desirable to ascertain how the existing state of affairs had come about, and what grounds there were for the preference generally shown for a metre-gauge line rather than a light line of standard

gauge. When the 5-foot 6-inch gauge was first introduced into India, about 1850, the carriages were 8 feet 6 inches wide over the body, the roof projecting on each side, as a protection from the sun, to a width of 10 feet 6 inches. The lamp-covers and engine-funnel extended to a total height of 13 feet 6 inches. The coping of platforms was 5 feet 3 inches from the centre of the track, and the width over the footboards of vehicles was 10 feet, the width over open doors being nominally limited to 13 feet. The tracks were spaced 13 feet 6 inches between centres in stations, and 12 feet elsewhere, and the fixed structures generally were arranged to give suitable clearance to an open door; but on lines used only for goods-traffic the lateral distance from the centre-line was in some cases only 5 feet 6 inches to 6 feet. There had been no great difficulty in subsequently increasing the width over body and floor to 9 feet, raising the roof a little, and carrying lateral sunshades down from the eaves for a depth of about 3 feet. More recently the width over body had been increased to 9 feet 6 inches, but the width at the floor of passenger-vehicles remained 9 feet, and the rest of the space up to the gauge-line of 10 feet 6 inches was reserved for door-fastenings, hand-rails, lamps, etc., a detail not noted on the diagrams which accompanied the Paper. A few years ago one railway constructed, on the strength of a similar diagram, a number of wagons 10 feet 6 inches wide over body, but some of the older lines refused to accept them, and they were rebuilt to the narrower width. These "moving dimensions" were considerably less than the gauge might carry, but they could not be appreciably increased without altering existing structures, tunnels, etc., on the older lines. When the metre gauge was introduced, about 1870, a much higher ratio of loading-dimensions to gauge was adopted, the width over roofs and sunshades being 8 feet 6 inches, over body and floor 7 feet, and over footboards 8 feet 2 inches; dimensions which allowed metre-gauge vehicles to use the same platforms as the standard-gauge by inserting a third rail, though the floor-level was then 15 inches to 18 inches lower. The width over body was subsequently increased to 7 feet 9 inches, the width at floor remaining 7 feet; and the rest of the space between this and the gauge-line of 8 feet 6 inches was reserved for hand-rails, etc., as in the standard gauge. The actual overhang beyond the gauge was therefore 1½ inch to 2¾ inches more on the metre than on the standard gauge. The result was that while the standard gauge carried only five passengers on each third-class transverse seat, the metre gauge carried four, and had corresponding relative advantages in [illegible]rriage of bulky goods. On standard-gauge railways recently [illegible]ted the fixed dimensions had been arranged to admit of some [illegible]t

Mr. Wolley Dod.

Mr. Wolley-Dod. of the present limited loading-gauge; but little had been done in this direction on the older lines. Improvement of these conditions on the standard gauge would tend to reduce the preference for the metre gauge. With regard to the standard of weight, it had frequently been pointed out that this depended not on the distance apart at which the rails were laid, but on their strength and on that of the bridges. There was doubtless a limit to the weight possible on any gauge, but in practice this limit was seldom likely to be reached in the near future. At the time the metre gauge was first introduced, the maximum load on a pair of wheels of the goods-stock of standard gauge was 9 tons; but this maximum was very seldom reached, and few vehicles exceeded 8 tons on a pair of wheels. The rails first used on the metre gauge weighed 36 lbs. per yard; had they been placed 5 feet 6 inches apart instead of 3 feet $3\frac{3}{8}$ inches they would certainly have carried fully-loaded standard-gauge vehicles at low speeds. The 36-lb. rails were soon superseded by 40-lb. iron and $41\frac{1}{4}$-lb. steel rails, which were quite equal to carrying standard-gauge vehicles. The weight per lineal foot of these standard-gauge wagons was 0·8 ton, less than the equivalent live load for which metre-gauge girders, except those of large span, were then designed; so that with suitable engines, the same girders as were then used on the metre gauge would have carried low-speed broad-gauge trains. Now the maximum load on a pair of wheels of the goods-stock of standard-gauge was 12 tons (except in very special cases), while the ordinary metre-gauge rail weighed 50 lbs. per yard on main lines and $41\frac{1}{4}$ lbs. on branches. The latter could at low speeds carry standard-gauge wagons, though the former would be preferable. It would no doubt be more economical in the long run to lay heavier rails, say, weighing 55 lbs. per yard, which was an increase of $33\frac{1}{3}$ per cent. over $41\frac{1}{4}$ lbs. The maximum weight per lineal foot over buffers of standard-gauge goods-stock was 1·2 ton, which was less than the equivalent live load for which metre-gauge girders of small span were now designed, and not greatly in excess of that for long spans. There was no difficulty in designing a standard-gauge engine to come within these limits; in fact, some had been built within the last 6 years, and many older ones were still running. It was, therefore, possible now to make a standard-gauge line, suitable for carrying fully-loaded vehicles, using the present metre-gauge rails and increasing the length of sleepers by 2 feet 3 inches only, or about 37 per cent., and the width of formation by about 2 feet 6 inches, the average cost of which would certainly not exceed 1,200 rupees or £80 per mile. But in most cases it would be wiser to increase the weight of the rails by $33\frac{1}{3}$ per cent., to increase the scantling as well as the length of

Mr. Wolley Dod.

sleepers, thus doubling their cost, and to add about 10 per cent. more ballast. Taking the usual prices of these articles on the metre gauge, this addition would increase the cost of permanent way and ballast by about 45 per cent. The formation would be widened 2 feet 6 inches, which, under average conditions, would increase its cost about 8 per cent., and the girders would be designed to carry about 25 per cent. more live load, which, coupled with the wider formation, would increase the cost of all bridges, including arches, by less than 12½ per cent. on the average. It was not to the point to compare a standard-gauge railway built 40 years or 50 years ago, when all materials were much more expensive, and engineers had less experience of construction by methods suitable to India, with a metre-gauge line recently constructed. What was wanted was to find out what the latter would have cost had it been made as a cheap standard-gauge line. An existing example might therefore be taken, details of which could be found in the Railway Administration Report for 1903. For comparison the metre-gauge Bengal and North-Western, and the standard-gauge Oudh and Rohilkhand railways might be selected. The Bengal and North-Western system included (*a*) the Tirhut State railway, of which 277 miles were constructed by the State between 1874 and 1890, to which 240 miles, mostly constructed through the agency of the Bengal and North-Western railway, had since been added, and (*b*) the Bengal and North-Western railway proper, begun in 1882, with 376 miles open in 1890, and 813 miles in 1903: the total length of the system being thus 1,330 miles. The more important parts were laid with 50-lb. and the less important with 41¼-lb. rails, and except as regarded price of materials, there was no great difference between the older and more recent parts of the system, and there were no curves which could not readily be traversed by any broad-gauge stock. The Oudh and Rohilkhand system consisted of 694 miles taken over from the old "guaranteed" company in 1889, most of which was constructed between 1864 and 1876 in the style and with the absence of regard for economy usual at that period; since 1890 additional lines constructed by the State had increased the total length to 1,101 miles. Nearly the whole was now laid with 75-lb. rails. The actual cost per mile under each head was shown side by side in the Table on p. 128, in thousands of rupees. The first five of these items were unaffected, or affected only to a very small extent, by the gauge of the line; but they had cost 31·52 thousand rupees per mile on the Oudh and Rohilkhand, against 21·81 thousand on the Bengal and North-Western, a difference of 44 per cent. Again, as regarded the quantity of bridgework, on

Mr. Wolley-Dod.

	Bengal and North-Western. Metre Gauge. 1,330 Miles.	Oudh and Rohilkhand. 5-Foot 6-Inch Gauge. 1,101 Miles.
	Thousand Rupees.	Thousand Rupees.
Preliminary expenses	0·70	1·22
Land, general charges, telegraph and sundries	9·08	10·69
Fencing	1·72	3·07
Plant	2·25	2·80
Stations and buildings . . .	7·86	13·74
Formation	5·69	4·65
Rolling stock	14·48	19·81
Bridges.	17·04	31·50
Ballast and permanent way . .	21·01	37·48
Total, thousands of rupees	79·83	124·96
or £	5,322 per mile.	8,331 per mile.

the Oudh and Rohilkhand there were 22,240 lineal feet in nine large bridges—five of them over the Ganges—which had cost 1,643·85 thousand rupees, or about 15 thousand rupees per mile, against 14,400 lineal feet in five bridges on the Bengal and North-Western, costing 1,184·07 thousand rupees, equal to a little less than 9 thousand rupees per mile, a difference of over 6 thousand per mile on this head alone. There was very little difference between standard and metre gauge in the cost of bridges of this class. Adding the percentages previously indicated to the cost of the metre gauge, the following figures were obtained:—

	Thousand Rupees.
8 per cent. on formation	0·46
12½ per cent. on bridges	2·13
45 per cent. on ballast and permanent way	9·45
Total (about 15 per cent. on total capital cost) . . .	12·04

making the total cost per mile 91·87 thousand rupees, for a standard-gauge instead of a metre-gauge line; and the difference of 33 thousand rupees (£2,200) per mile between this figure and the actual cost of the Oudh and Rohilkhand railway was due to the difference in character of the country, in the standard of line and equipment provided, and in the prices paid for materials and work. When the working-expenses of the two lines were compared, differences in many of the items became at once apparent, which were not due to the difference in gauge. The conditions on the Oudh and Rohilkhand railway, which had no less than six important junctions with the through main line of the East Indian and North-Western

railways, at most of which a comparatively frequent service of fast trains was required, did not conduce to economy of working. The figures for working-expenses applied also to certain branches worked but not included in the capital cost, so that the mileage worked in the Table on p. 130 was greater than that to which the previous Table applied. If the nature of the services, rates, etc., on the two lines were the same, most of these items would be nearly proportional to the gross earnings, while others would increase in a smaller ratio than the gross earnings; anything over and above this difference was due to a more economical method of working and an inferior service, as well as to difference of gauge, which did not in any way affect most of the items. Other figures in the Administration Report enabled an analysis to be made of the item fuel. These figures showed that the average cost on the Oudh and Rohilkhand railway of coal (reckoning $\frac{2}{5}$ of the weight of wood fuel as the equivalent weight of coal) was 35 per cent. higher than on the Bengal and North-Western railway, due chiefly to greater distance from the collieries. Adding 35 per cent. to the cost of fuel gave Rs. 466 per mile, which, divided by 7,780, the gross earnings per mile excluding the steam-boat service, showed the amount of coal used per rupee of gross earnings on the Bengal and North-Western railway to be about 5½ per cent. more than on the Oudh and Rohilkhand railway, although the average speed of the trains was less, and the ratio of paying load to dead load was actually higher. The Table on p. 131 showed that the two systems ran about the same number of passenger-trains. The Oudh and Rohilkhand railway provided a train for every 135 third-class passengers, whom it carried 3·49 in each compartment constructed to hold 10; while the Bengal and North-Western railway only provided a train for every 203 passengers, whom it carried 3·79 in a compartment constructed to hold 8. The former was a better service from the passenger's point of view, and likely to yield the railway less profit, even though the fares were higher. The figures from the returns of goods-traffic on p. 131 indicated a probability of better returns on the Bengal and North-Western railway. Revenue stores and materials for construction on home line, which made up nearly the whole of the rest of the traffic, were carried nominally at cost price. All the foregoing figures showed that the difference in capital cost, and the larger percentage of profit on gross earnings per mile, were due not so much to difference in gauge as to other causes; while the quantity of fuel per unit of receipts was larger on the metre than on the broad gauge, t[illegible] the speed was less, and the receipts per ton-mile of goods-traf[illegible] per train-mile of passenger-traffic were larger. The metre

Mr. Wolley-Dod.

Mr. Wolley-Dod.

COMPARATIVE TABLE OF WORKING-EXPENSES FOR 1903, OF THE BENGAL AND NORTH-WESTERN AND OUDH AND ROHILKHAND RAILWAYS.

	Bengal and North-Western taken on 1,348 Miles worked.	Oudh and Rohilkhand taken on 1,213 Miles worked.
	Rs. per Mile.	Rs. per Mile.
General superintendence, engineering	191	259
Permanent way { Wages	179	275
Permanent way { Materials	223	410
Repairs of bridges, etc.	144	200
Conservancy of rivers	13	10
Repairs of stations and buildings	95	186
Items not allocated	91	176
Total engineering expenses	936	1,516
General superintendence, locomotives	75	121
Wages of drivers, firemen, cleaners, etc.	165	245
Fuel	338	685
Water	30	26
Oil, tallow, etc.	37	55
Maintenance and renewal { Locomotives	167	273
Maintenance and renewal { Machinery	4	27
Items not allocated	75	338
Total locomotive-expenses	891	1,770
General superintendence, carriage and wagon	26	27
Repairs and renewals { Coaching-vehicles	59	265
Repairs and renewals { Goods-vehicles	77	91
Repairs and renewals { Machinery	4	9
Cleaning and oiling	50	76
Items not allocated	−12	3
Total carriage- and wagon-expenses	204	471
General superintendence, traffic	115	145
Station staff	293	532
Train staff	83	171
Fuel, lighting and stores	75	123
Clothing	13	20
Printing, stationery, etc.	39	63
Delivery and collection of goods	23	3
Items not allocated	19	56
Total traffic	660	1,113
Total general and miscellaneous	652	777
Grand total, excluding steam-boats	3,343	5,647
Cost of steam-boat services	254	0
	3,597	5,647
Gross earnings per mile	8,383	11,969
Deduct for steam-boat service	603	0
Gross earnings, excluding steam-boat service	7,780	11,969

Mr. Wolley-Dod.

PASSENGER-TRAFFIC ON THE BENGAL AND NORTH-WESTERN AND OUDH AND ROHILKHAND RAILWAYS.

	Total Number carried.	Rupees received. Thousands.	Average Fare per Mile. Pies.	Pence.	Average Distance travelled. Miles.	Average Number in each Train.	Ratio of Number to Capacity hauled. Per Cent.	Average Number of Vehicles in a Coaching Train.
				Bengal and North-Western Railway.				
First-class passengers	17,800	52	12·24	1·02	46·25	0·42	2·61	1·70
Second-class passengers	37,700	62	5·65	0·47	55·48	0·95	4·19	1·50
Intermediate passengers	169,300	118	2·99	0·25	44·96	3·46	9·41	1·66
Third-class passengers	11,850,100	4,655	2·00	0·167	37·76	203·33	47·43	14·79
Special tickets	1,700	1	3·79	0·316	40·00	..	..	..
Total or average	12,076,600	4,888	2·05	0·17	37·92	208·16	..	22·09
				Oudh and Rohilkhand Railway.				
First-class passengers	34,600	207	11·81	0·98	97·14	1·32	4·43	1·34
Second-class passengers	116,200	282	5·22	0·435	89·34	4·07	15·85	1·15
Intermediate passengers	804,700	566	3·03	0·250	44·61	14·08	27·89	1·45
Third-class passengers	7,946,400	4,338	2·44	0·203	43·36	135·11	34·91	7·08
Total or average	8,901,900	5,443	2·65	0·22	44·29	154·58	..	11·02

GOODS-TRAFFIC ON THE BENGAL AND NORTH-WESTERN AND OUDH AND ROHILKHAND RAILWAYS.

		Bengal and North-Western Railway.	Oudh and Rohilkhand Railway.
General merchandise carried	Thousands of tons	1,327	1,421
Average rate per ton-mile		6·33 pies = 0·53*d.*	5·52 pies = 0·46*d.*
Average distance a ton of goods travelled	Miles	127·24	109·14
Average percentage of freight on capacity hauled	Per cent.	45·34	41·94

Mr. Wolley-Dod. might have been made standard gauge for 15 per cent. more than its original cost, making no allowance for the saving in rolling stock due to uniformity of gauge, or in transhipping-arrangements. In the earlier days of the line the saving in working-expenses would probably not have covered the whole of this 15 per cent., though the public would have benefited; but the time would come, if it had not already arrived, when the saving would more than cover it. The standard-gauge line once made, its permanent way could be increased in strength when the traffic demanded it, to enable more powerful engines to be used, and heavier trains to run at higher speed, the ultimate capacity being practically double that of a metre-gauge line. Either to convert metre-gauge line or to double it would cost considerably more than if it had been made originally as a light standard-gauge line.

The Author. The AUTHOR, in reply, thought that Colonel Boughey was correct in saying that the original reason for the two gauges being adopted was that of expediency. His remarks on the transhipment question might be accepted as correct where the traffic was fairly light, but when it became heavy two remedies presented themselves. One was the alteration, to the gauge serving the port, of the entire narrow-gauge system behind, which might sometimes have many times the length and importance of the gauge entering the port; the other alternative was the admission of the inland system of different gauge to the port, as an independent line. It appeared to the Author, as had been shown already, that the second alternative was the correct remedy to apply. Transhipment at the port itself, from a line at some distance from the quay-wall, had been successfully carried out in America and elsewhere by transporters, and the Author saw no insuperable objection against it in India. Mr. Brunton's statement that delay in adopting uniformity of gauge meant extra expense might certainly be true in one sense, but if it was possible to effect a change at a reasonable cost, and if it was justifiable on the score of traffic, when it could be shown that it would pay, and could be carried out in detail, his objection to the necessity for immediate action would seem to be met. Mr. Cardew, the Author thought, wrote without full knowledge of the case when he assumed that the Southern Shan line was to be on a 2-foot 6-inch gauge. As regarded his remark that certain portions of the Burma railways were of double track, 16½ miles in a total of 12,000 miles was quite negligible. In speaking of the conversion of rolling stock, the Author depended on facts supported by the eminent locomotive engineers who had undertaken the conversion of the existing stock. In reply to Mr. Cardew's question, on which gauge the extra

haulage was calculated the Author explained that it was the metre gauge. As the Author had expressly ruled out the 4-foot 8½-inch gauge as the one to be adopted in any conversion, it was refreshing to find in Mr. Egerton an advocate who believed in it; but it was the cost which was the governing factor of conversion, and not the trouble or difficulty of converting rolling stock, permanent way and works, etc. The object of constructing the Cawnpore-Lucknow and other links on the metre gauge, which was so much deprecated by Mr. Egerton, was to allow goods and passengers to be carried from one system of metre gauge to another without break, and this was making the best use of the isolated systems of lines. Mr. Lart was incorrect in his views as to the need of rapid travelling in India. India, the Author was quite sure, was like every other country, and had progressive ideas of speed, comfort and safety, and the Railway Administrations would have to meet these needs for all classes. Whatever might be the merits of Mr. Molesworth's scheme for bringing the metre gauge into Calcutta, it was evident that when made it would have to embrace the whole of the metre-gauge system north of the Ganges and not one portion only. Mr. Preston's claim for favourable consideration of the 2-foot 6-inch lines, if confined to the hills, had some justification. The Author agreed that they should have no permanent place on the plains of India. But, as pointed out, these lines having been constructed under the Tramways Act, it was subsequently cheaper to increase their efficiency on the original width rather than to adopt a new gauge; hence their continued existence. Mr. Robertson was probably correct that 5 feet and 2 feet 6 inches represented the ideal gauges. The Author hoped that Mr. Robertson's caustic remarks on the speed of the 5-foot 6-inch gauge would in future be inappropriate. The criticisms of Mr. Shadbolt were allied to those of Mr. Egerton as far as his preference for the European gauge was concerned, and the Author found the same disregard to financial considerations which must govern the railway policy of India. Mr. Spring's conclusions were quite sound, as he based his arguments on the needs of the traffic of the country that had to be met by a limited purse. Mr. Sykes reasonably drew attention to the construction of light lines on the standard gauge being a necessary preliminary to uniformity, but he was inaccurate in calling the present system of independent development of two gauges ruinous. The surplus profit from the railway systems of India was a sufficient answer to this indictment. The Author referred Mr. Campbell Thomson to the reply to the oral discussion as to the elimination of certain railways in arriving at a fair basis of comparison. Mr. Wolley-Dod

The Author

The Author. was correct in pointing out that the loading-gauges of the two gauges did not vary in the ratio of the distance apart of the rails, but his remark that to convert or double the metre gauge would cost more than if the 5-foot 6-inch gauge had been originally adopted was rather beside the point when dealing with the existing problem. The Correspondence, taken as a whole, seemed to the Author to lead to the general conclusion that the necessities of the country's trade would be the ruling factor in bringing about uniformity.

---

6 February, 1906.

Sir ALEXANDER RICHARDSON BINNIE, President, in the Chair.

It was announced that the Associate Members hereunder mentioned had been transferred to the class of

Members.

ROBERT ADAM.
JOHN WEMYSS ANDERSON.
JOHN COWAN.
MICHAEL ELLIOT.
CLARENCE NOËL GOODALL.
JOHN HALLIDAY.
WALTER ANDREW HARPER.
GEORGE WALKER HERDMAN, M.A., B.Sc. (*Edin.*)
EDGAR PURNELL HOOLEY.
ARTHUR JAMES KNOWLES, B.A. (*Cantab.*)
ALBERT DE LINDE.
FREDERICK HOWARD LIVENS.
GEORGE TROTTER LYNAM.
PAUL LE JUGE DE SEGRAIS.
GEORGE WATSON.

And that the following had been admitted as

Students.

KRISHNA CHANDRA RAY CHOWDRY.
JOHN FREDERIC CRAIG.
JOHN HENRY DARE.
ALICK DARBY DRAPER.
GEORGE HALSTEAD, B.Sc. (*Manchester*).
GILBERT STANLEY HEATHCOTE, B.A. (*Cantab.*)
PERCY HOWARD.
FRAMJEE PESTONJEE KHAN, B.A. (*Cantab.*)
ERNEST CHENEY LAUGHTON.
WILLIAM REGINALD MCLAUGHLIN.
ELI MARSDEN.
WILLIAM THOMAS PARRY, B.Sc. (*London*).
JAMES EDWARD PIERCY.
GEORGE EDWARD SCOTT.
EDWARD WARNANT.
FRANZ WORKMAN.
EMANUEL HENRY WORMS.
WILLIAM GEORGE YEAMAN, B.Sc. (*Glas.*)

The Candidates balloted for and duly elected were: as

Members.

ROBERT ARTHUR DAWBARN.
RICHARD MOUNTFORD DEELEY.
HARRY EARLSTON GWYTHER.
JOHN LYLE HARRINGTON, B.Sc., B.A. (*Kansas*).
HENRY CHARLES KIDD.

Members—continued.

WILLIAM WALKER LACKIE.
JAMES BANNATYNE LEWIS, M.C.E. (*Melbourne*).
Professor MAGNUS MACLEAN, M.A., D.Sc. (*Glas.*)
CORYDON TYLER PURDY.
FRANK PRIOR PURVIS.
FRANK RIGBY.
MANSERGH DIAS ROBINSON.
ARTHUR MOLYNEUX SILLAR.

Associate Members.

MAURICE McCLEAN BIDDER.
THOMAS WIGSTON KINGLAKE CLARKE, B.A. (*Cantab.*).
HARRY STOWE COPPOCK, B.Sc. (*Wales*), Stud. Inst. C.E.
BERNARD D'OLIER DARLEY, Stud. Inst. C.E.
FREDERICK THOMAS ECROYD, Stud. Inst. C.E.
WILLIAM PERCIVAL GAUVAIN, Stud. Inst. C.E.
CHARLES HERBERT GEORGE.
HUMPHREY NOEL GILES, B.Sc. (*Victoria*), B. Eng. (*Liverpool*), Stud. Inst. C.E.
JOHN HADDIN, Stud. Inst. C.E.
WILLIAM HAWTHORNE, B.E. (*Royal*).
WILLIAM CAMPBELL HOUSTON, B.Sc. (*Glas.*)
HARRY OSCAR JOHNSON.
HENRY FORREST KERR, B.A.I. (*Dublin*).
ROBERT THOMAS McKAY.
DUNCAN ROBERT MACLACHLAN, B.Sc. (*Glas.*)
ERNEST EDWIN MANN, B.Sc. (*Victoria*), Stud. Inst. C.E.
CHARLES HAMILTON MITCHELL, B.A.Sc. (*Toronto*).
JAMES MUIRHEAD, B.Sc. (*Glas.*)
GEOFFREY PARKER, Stud. Inst. C.E.
FRANCIS BERTRAM ROBINSON, Stud. Inst. C.E.
WILLIAM HENRY STACEY, B.Sc. (*Birmingham*), Stud. Inst. C.E.
JAMES NEILSON STIRLING, B.Sc.(*Glas.*)
GILLIS SVENSSON, Stud. Inst. C.E.
PATRICK CHARLES YOUNG, B.A. (*Cantab.*)

Associates.

JULIO BRANDÃO (*Sobrinho*).
CHARLES EDWARD HAWKINS.

The discussion on the Paper "The Railway-Gauges of India," by Sir Frederick Upcott, occupied the evening.

---

13 February, 1906.

Sir ALEXANDER B. W. KENNEDY, LL.D., F.R.S., Vice-President, in the Chair.

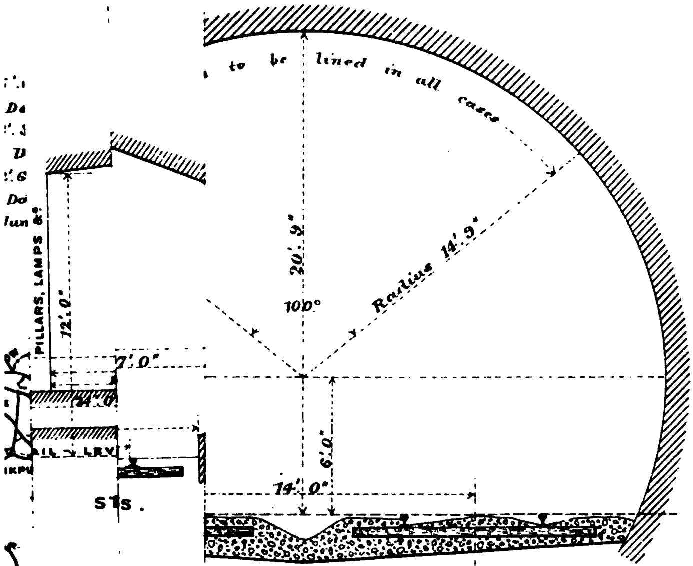
The CHAIRMAN said he regretted to have to announce that the Council had heard of the death of their colleague, Mr. Charles Napier Bell, who had represented Australasia on the Council for some time, and whose services had not been less in that he had not been able to be present at the Council Meetings. The Council had passed the following resolution, which he was sure the members would endorse: "That the Council have learned with deep regret of the death of their colleague, Mr. Charles Napier Bell, and desire to offer their sincere condolences to his family."

The discussion on Sir Frederick Upcott's Paper was continued and concluded.

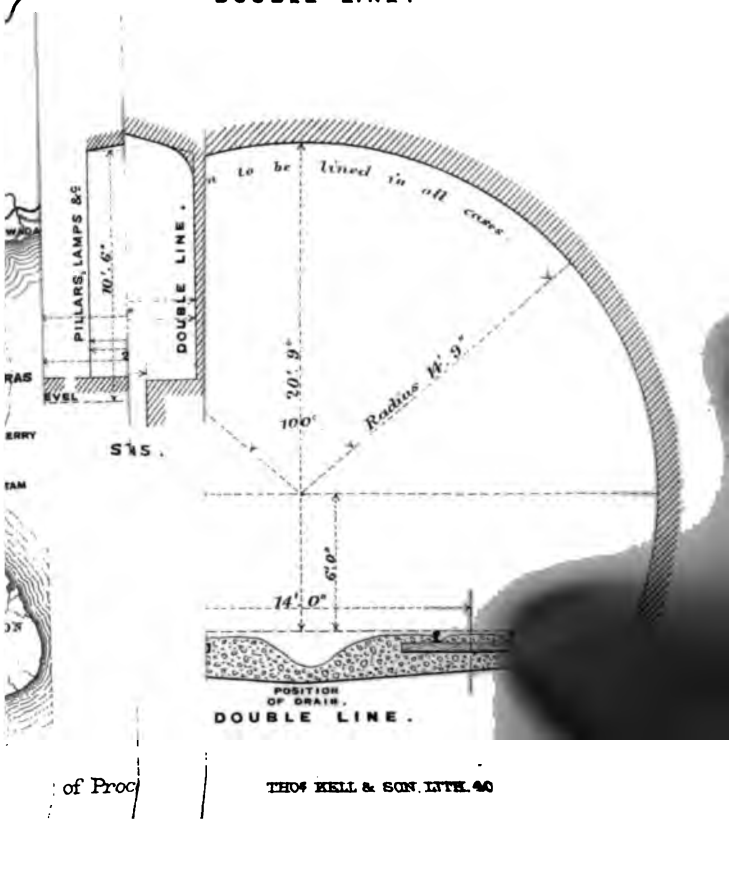
LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
DUKE STREET, STAMFORD STREET, S.E., AND GREAT WINDMILL STREET, W.

H E

PLATE 2.



DOUBLE LINE.

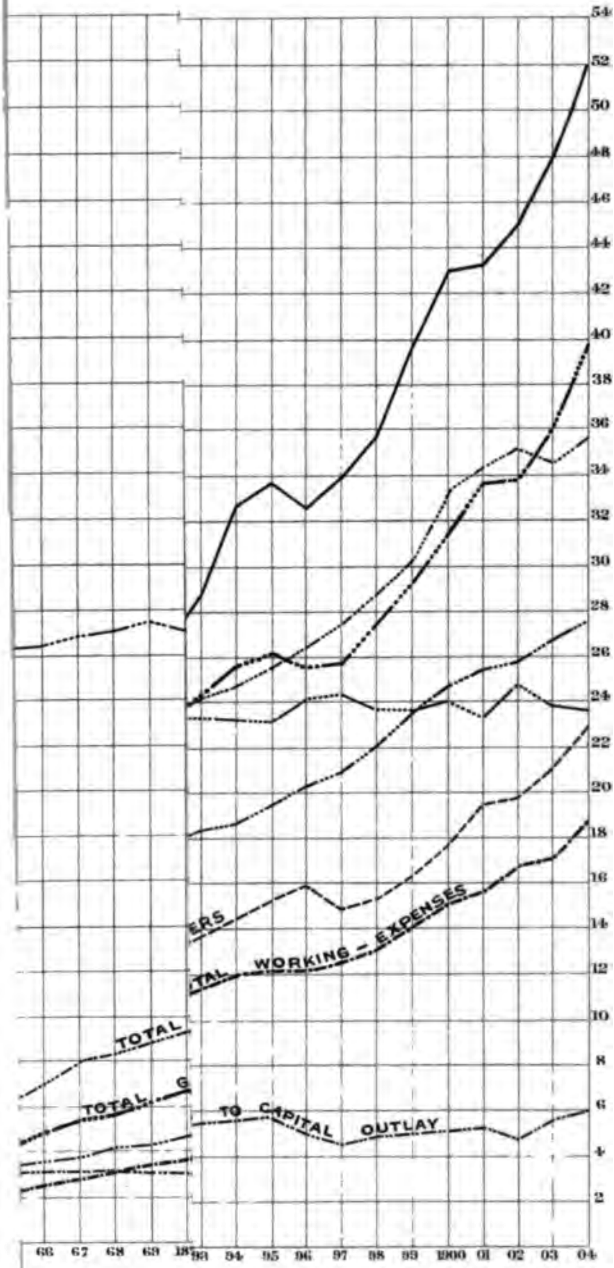


DOUBLE LINE.

of Proc

THOS KELL & SON. LITH. 40

PLATE 3

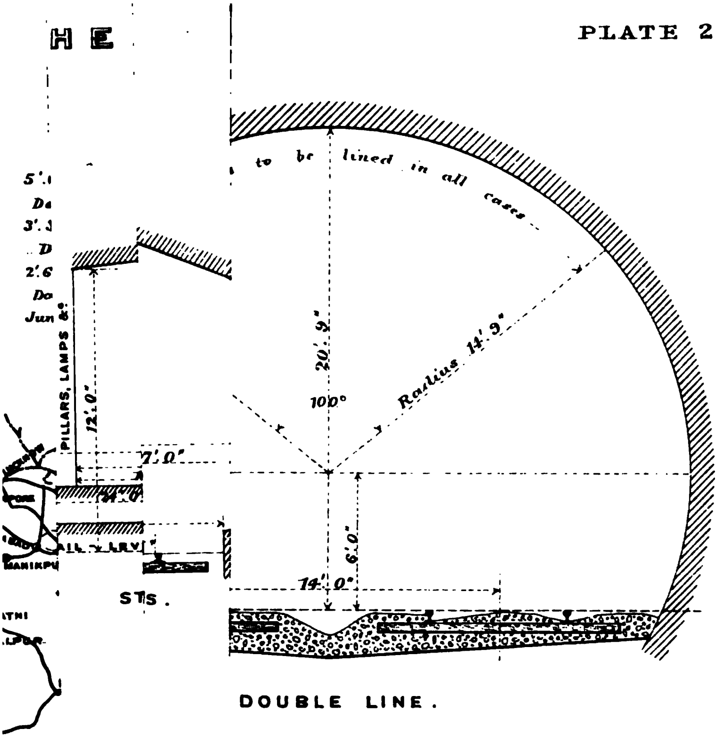


Goods Tonnage : Unit – 1,000,000 Tons
Nº of Passengers : Unit – 10,000,000

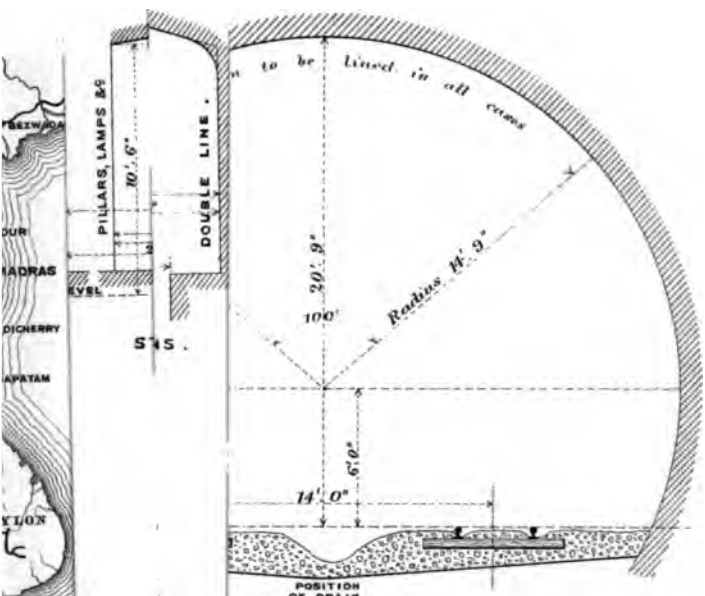
THOs BELL & SON LITH 40 KING ST COVENT GARDEN

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED,
DUKE STREET, STAMFORD STREET, S.E., AND GREAT WINDMILL STREET, W.

PLATE 2.



DOUBLE LINE.



DOUBLE LINE.

of Proc

THOS KELL & SON. LITH. 40 KING ST COVENT GARDEN.